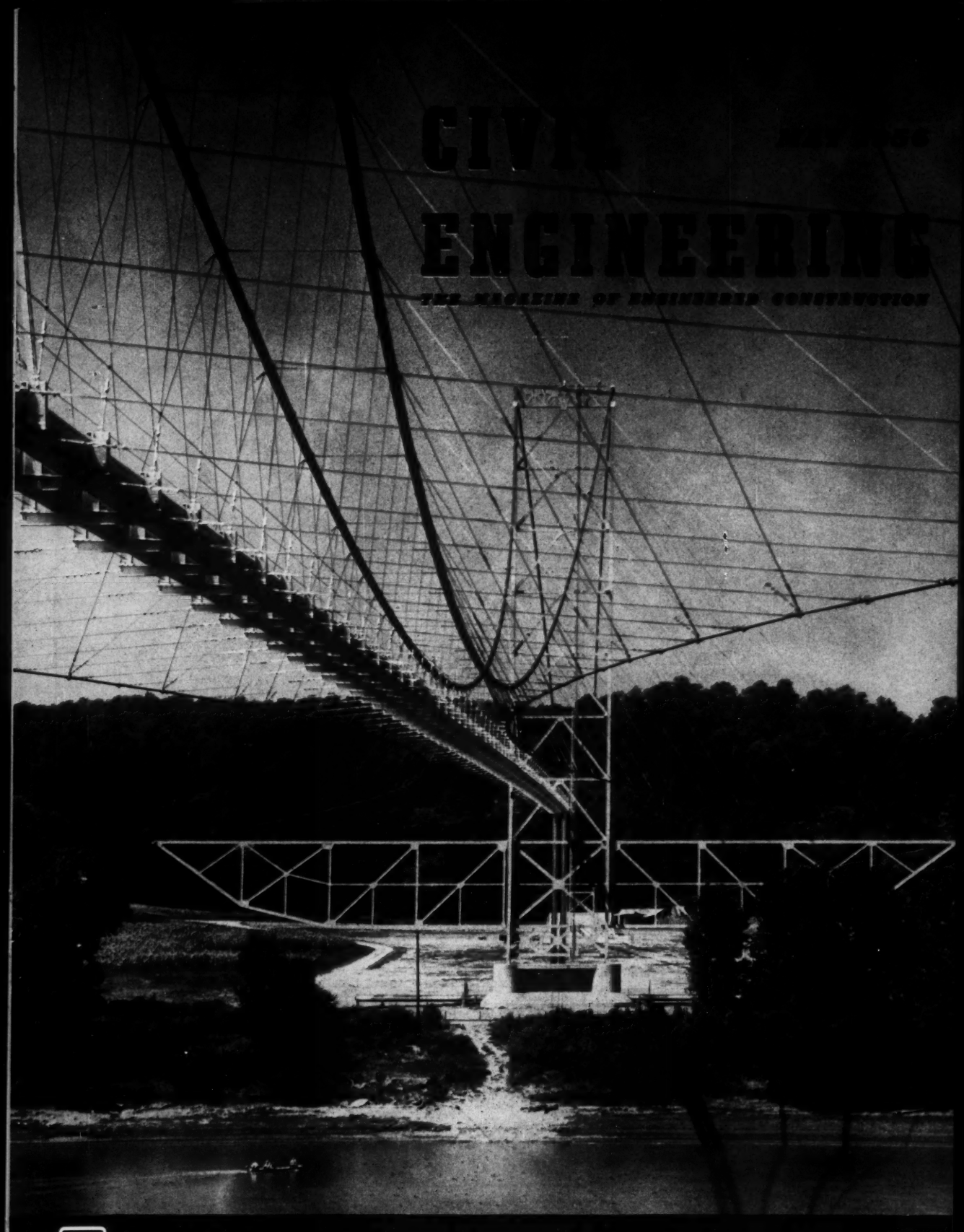


CIVIL ENGINEERING

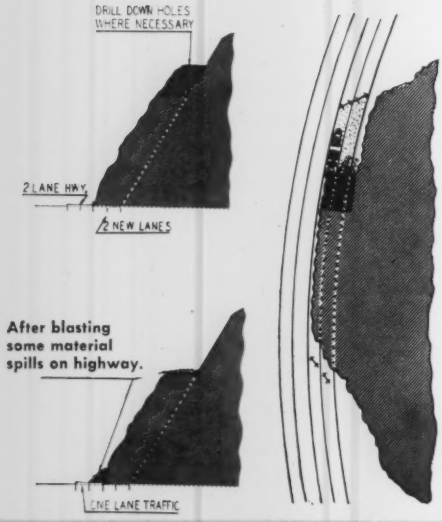
THE MAGAZINE OF ENGINEERED CONSTRUCTION

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

NATURAL GAS LINE JUMPS 2,150 FT OVER MISSISSIPPI RIVER

SEE ARTICLE ON PNEUMATIC CAISSON PIERS BY JOHN NEWELL

Highway Widening Jobs Need Not Obstruct Traffic



Contractors can take highway widening jobs without building bypass roads to carry traffic.

The busy highway shown above is being widened from two lanes to four lanes using the method described at left.

The problem was solved by keeping the trucks and excavating equipment off the highway so that it remained open for traffic except at intervals when shooting was necessary.

The Eimco 105 Tractor-Excavator was ideally suited to this type of job. It loads large trucks full from the end and cleans up the big boulders quickly. With the Eimco operating in a straight line, forward to dig and load and reverse, with the bucket moving overhead, to discharge.

Digging in dirt and consolidated material can often be accomplished without blasting the material at all. The Eimco 105 will load in dirt at the rate of 10 yards per minute and in rock the rate of loading is 6-7½ yards per minute depending on the material.

Eimcos are heavy-duty machines built to handle the toughest kind of jobs. They can apply more thrust force at the digging lip than larger equipment costing several times as much.

Write for complete information on Eimco 105 Tractors.

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Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

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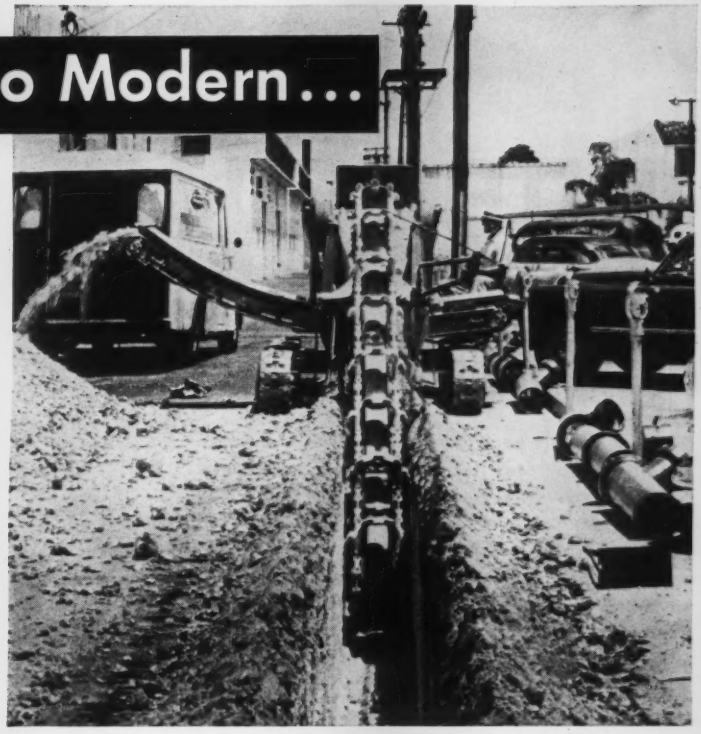
B-187

When Cities Go Modern...

CLAY PIPE SEWERS GO IN



CORAL GABLES, FLORIDA, had a population of only 8,300 people in 1940. Today, the population has zoomed to more than 30,000—and public health facilities are being modernized to meet this amazing growth. A 259,000-foot bond-financed sewerage system, costing $3,372,000, is being installed.

Vitrified Clay Pipe is the safe choice of city officials, because it's sure to give dependable, trouble-free service long after the bonds are retired.

Clay Pipe is not only the *safe* material, but the practical material for municipal sewerage. A wide variety of new jointing methods and materials, developed through Clay Pipe research, insure a system that holds infiltration to a minimum, even in Florida's high-water-table areas. And Clay Pipe is the economical material, because its cost-per-year-of-service is the lowest. Where public health is at stake, why take chances on substitutes? Specify and install Vitrified Clay Pipe . . . guaranteed for 50 years.

FOR CORAL GABLES, FLA.—W. T. McIlwain, City Manager
CONSULTING ENGINEERS—M. B. Garris and Associates, Coral Gables, Fla.
Smith and Gillespie, Jacksonville, Fla.

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CLAY PIPE NEVER WEARS OUT!

NATIONAL CLAY PIPE MANUFACTURERS, INC.
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C-256-1

Progress in Public Health - Through Clay Pipe Research

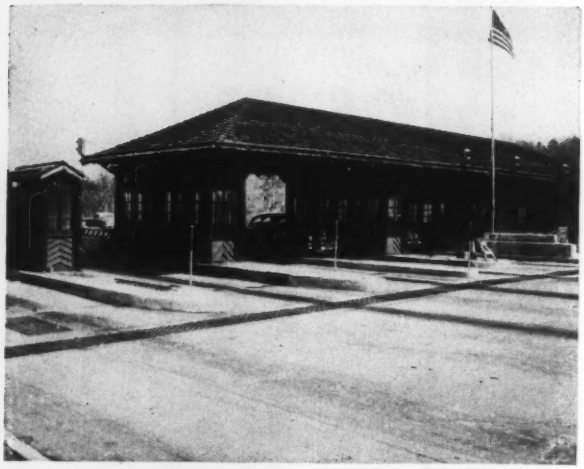
CIVIL ENGINEERING, May 1956. Vol. 26, No. 5. Published monthly by the American Society of Civil Engineers. Publication office 20th and Northampton Streets, Easton, Pa. Editorial and advertising departments at ASCE Headquarters, 33 West 39th St., New York 18, N. Y. Entered as second class matter September 23, 1930, at the Post Office, Easton, Pa., under Act of August 24, 1912, and accepted for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 5, 1918

BORDEN
First IN FLOOR GRATING

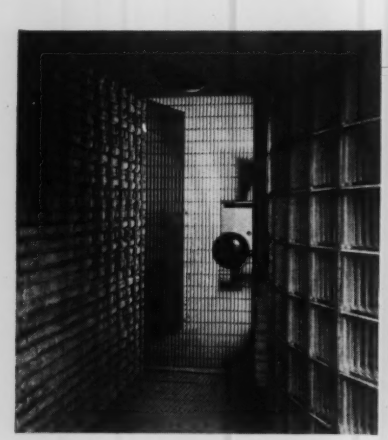
USES OF GRATING . . . WHERE ONLY BORDEN QUALITY WOULD DO . . .

Here on this page are a few of the many new or unusual uses for grating being pioneered every day. Each is an exacting job where only standards of quality equal to BORDEN'S will do.

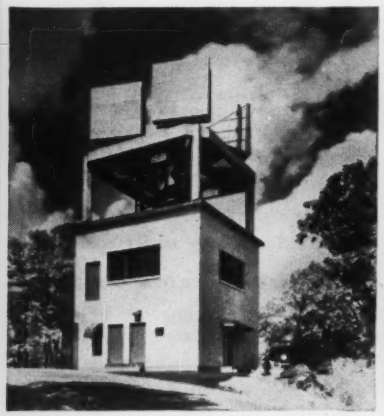
And remember . . . BORDEN manufactures every type grating in ferrous and non-ferrous metals.



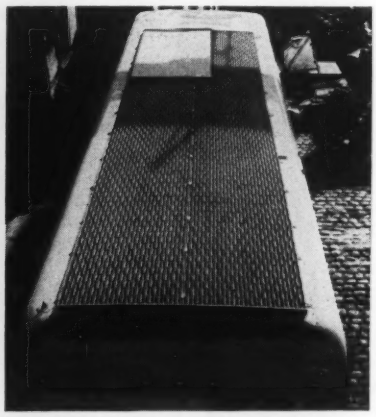
ON THE MERRITT PARKWAY . . . The recently installed Borden Roadway Grating shown here helps solve a drainage problem. Over 80% open, these Borden gratings give years of durable, minimum-maintenance service. And remember, SPECIFY BORDEN and you specify the best.



Only the finest precision manufacturing would satisfy the architect who designed this door. BORDEN is recognized as a leader in quality, custom-manufactured gratings.



Television relay stations and radar stations that gird our continent have adopted grating as standard outside platform material. It will not collect snow as most other platforms will.



Wherever this Color Television truck goes, whatever the assignment of the reporters who must mount its roof, Borden riveted *serra-crimp* grating will mean surerfooting —even in ice or snow.

BORDEN METAL PRODUCTS CO.

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VOL. 26 • NO. 5

THE MAGAZINE OF ENGINEERED CONSTRUCTION

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Two Flex-Plane Finishers used in tandom by A. J. Baltes Construction Co., on section of Ohio Turnpike

Western Contracting Co. operated two more on still another section of Ohio pike.

FLEX-PLANE

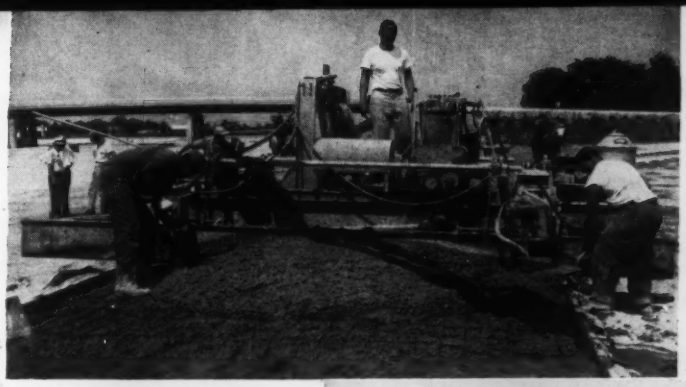
J. C. O'Connor and Sons operate Self-Widening Flex-Plane on section of Indiana Turnpike.

J. A. Tobin uses Flex-Plane working low slump concrete on section of U. S. 69 near Kansas City, Mo.

Heltzel — THE HELTZEL STEEL FORM AND IRON CO. — WARREN, OHIO

Flex-Plane — THE FLEX-PLANE ROAD JOINT MACHINE COMPANY — MECHANIZED CONSTRUCTION EQUIPMENT — WARREN, OHIO

WORLD'S LARGEST BUILDER



Self-widening machine used by Peter Kiewit on a midwestern turnpike interchange.

The Flex-Plane machine takes gradework in stride. Here Harrison Construction Co. works cloverleaf with a self-widening unit.

....the nation's most popular Finishing Machine

9892

Here's the finishing machine that has outsold all others for the past two years. The Flex-Plane has been the most flexible machine of its type ever built . . . and the 1956 model is no exception.

Upon a sturdy triple-lap frame, that extends hydraulically at the flick of a finger, is a power-packed engine that will easily handle the toughest finishing jobs. Users often work them without spreaders.

There is the Flex-Plane originated hydraulic transportation rig that transforms the machine into its own trailer in a matter of seconds. And, the Flex-Plane Self-Widening feature, that proved so popular last year, has been improved for 1956.

Add to these outstanding features the new Flex-Plane screed that holds rigid and true under any condition, yet takes a crown speedily, with a minimum of down time. Remember, too, Flex-Plane screeds are outside the frame where they belong for easy maintenance and better finishing.

Again we say, look them all over, talk to users, and we're sure you, like dozens of other leading contractors, will specify Flex-Plane Finishers from this point on.

THE FLEXIBLE ROAD JOINT MACHINE COMPANY
7200 Thomas Road Warren, Ohio

While working turnpike Calumet Construction Co. found Flex-Plane flexibility paid dividends.

On Garden State Parkway the Weldon Construction Co. put their second Flex-Plane through its paces.

The Union Building and Construction Corporation uses a pair of Flex-Planes to finish slabwork on Indiana Turnpike.

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IRVING GRATINGS UNEXCELLED From Every Angle!

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4. Prior to shipment gratings are carefully inspected for conformity to specifications and to Irving high standards of quality.

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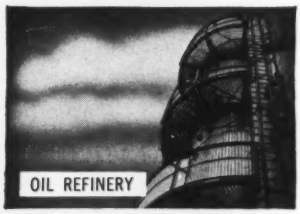
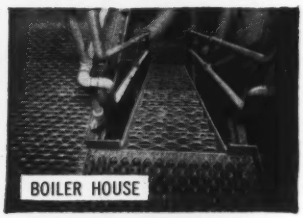
- Costly mistakes are avoided by utilizing up-to-date engineering skill and valuable experience unique with Irving.
- Irving quality gratings require minimum maintenance.
- Irving reputation of over 50 years of customer satisfaction is your guarantee of effective grating application.

Performance-Wise:



Non-skid; fireproof

Strong; self-draining



Self-ventilating; durable

Irving ALUMINUM Gratings– rustproof, sparkproof, lightweight

PIONEERS of the OPEN METAL FLOORING INDUSTRY

ESTABLISHED 1902

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Plants:
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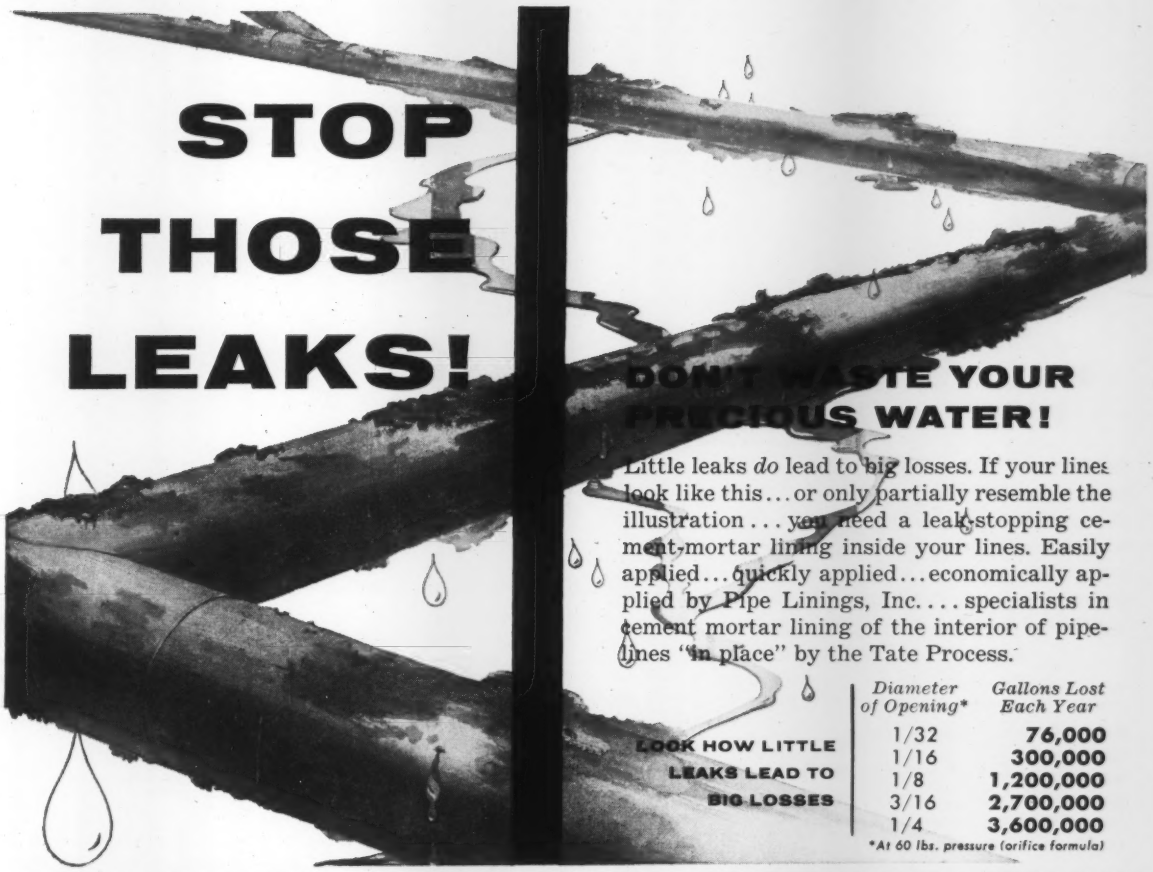
Write today for our illustrated catalog containing engineering data on Irving Riveted, Welded and Press-locked gratings that will save you time and money!

STOP THOSE LEAKS!



DON'T WASTE YOUR PRECIOUS WATER!

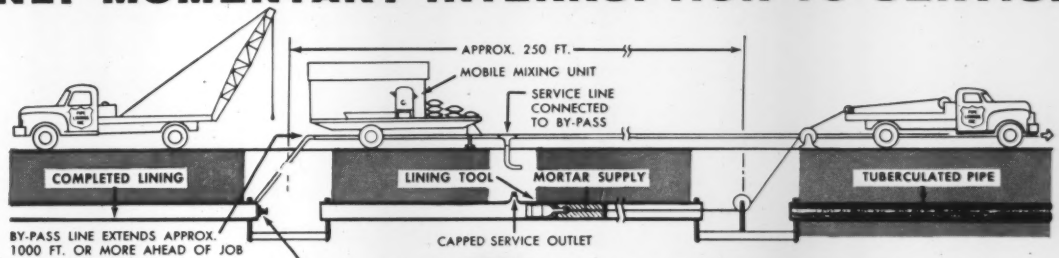
Little leaks *do* lead to big losses. If your lines look like this... or only partially resemble the illustration... you need a leak-stopping cement-mortar lining inside your lines. Easily applied... quickly applied... economically applied by Pipe Linings, Inc.... specialists in cement mortar lining of the interior of pipelines "in place" by the Tate Process.

LOOK HOW LITTLE LEAKS LEAD TO BIG LOSSES

*Diameter of Opening**	*Gallons Lost Each Year*
1/32	**76,000**
1/16	**300,000**
1/8	**1,200,000**
3/16	**2,700,000**
1/4	**3,600,000**

*At 60 lbs. pressure (orifice formula)

ONLY MOMENTARY INTERRUPTION TO SERVICE!



The economical way to line pipe 4" to 16" in diameter "in place"! A temporary pipeline laid parallel to the existing pipe serves the customer while work is being done. The existing pipe may be cleaned and lined at a rate of approximately 750 feet per day. Cement mortar linings normally 3/16" to 1/4" thick are applied at a pressure of approximately 100 pounds per square inch. Leaks are stopped... water loss is eliminated... operating costs are reduced.

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New pipe performance • Prevents leakage • Restores full flow coefficients • Reduces pumping and maintenance costs • Protects against corrosion, contamination and water discoloration... at much less than the cost of installing a new line.

Note: Pipe Linings, Inc. lines pipe 16" to 144" in diameter economically too... using the Centriline Process.

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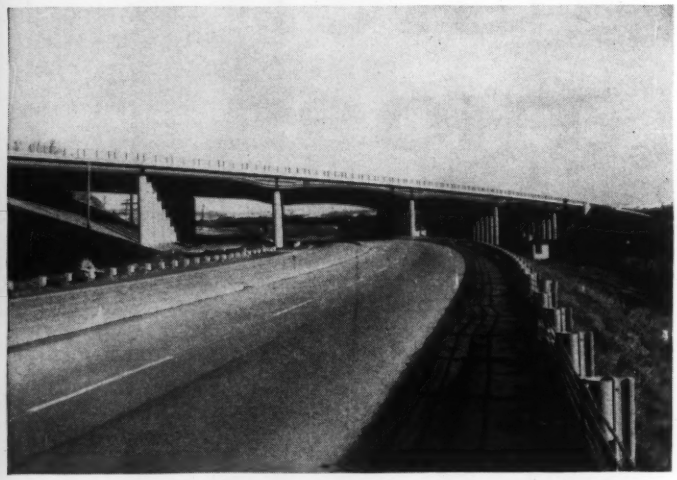
Have better appearance... require less maintenance...

Yet cost less to build...

WHY don't you design all bridges and buildings for welding



100% welded deck cantilever plate girder bridge for New York Thruway. Has 6 spans totaling 775 feet. Fabricated and erected by Phoenix Bridge Company, Phoenixville, Pa. Designed in office of C. F. Blanchard, Deputy Chief Engineer, New York State Department of Public Works, Albany, N. Y.

COST SAVINGS OF 15% TO 20% REALIZED IN WELDED BRIDGE DESIGNS

FOR reasons of economy, increased public safety and pleasing appearance, welding has become the standard for deck highway bridges in the State of New York. When continuous design (made possible by welding) is used, overall depths of bridge deck are reduced to afford necessary headroom under bridge at maximum economy. Savings in foundations and fills are substantial and are in addition to savings in steel, a cost which alone averages 15% to 20% over similar riveted structures.

Studies in Structural Arc Weldings are available to designers and structural engineers by writing:

THE LINCOLN ELECTRIC COMPANY

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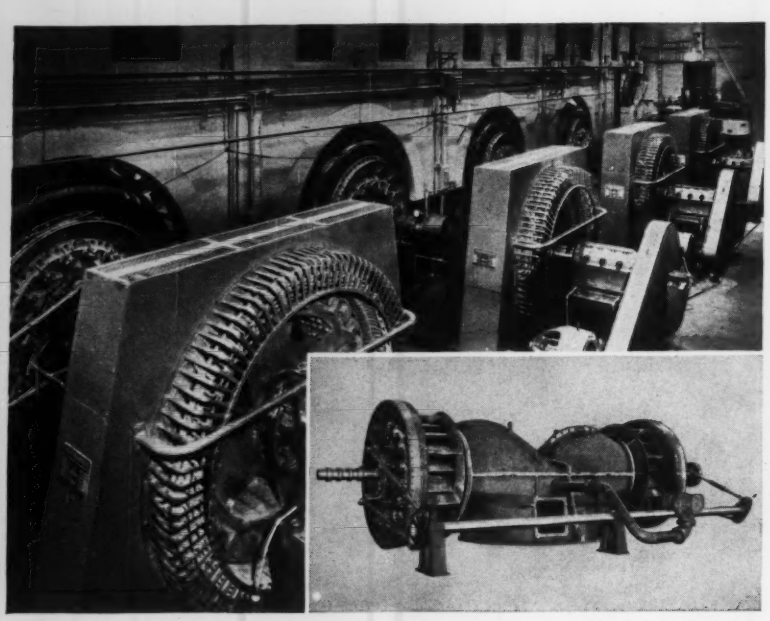
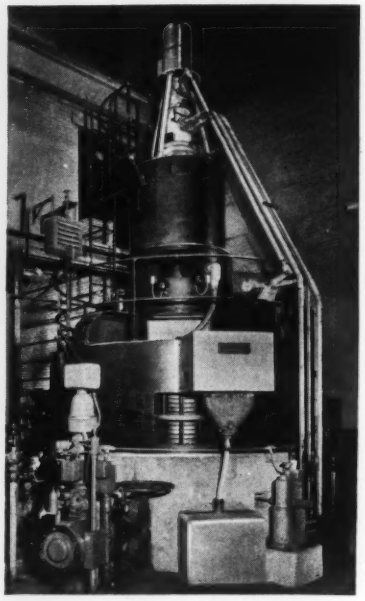


Horizontal generating units are each driven by a pair of modernized SMS-Francis turbines shown (inset) during shop assembly.



At remote end of the power house, a vertical SMS-Kaplan unit, mounted in a concrete pressure flume provides flexibility of operation.

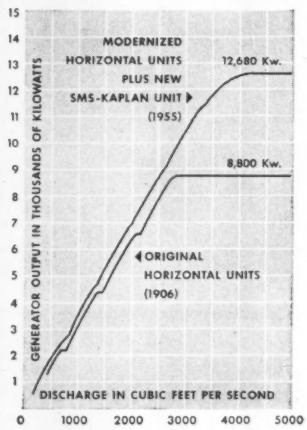
Consulting Engineers: Pioneer Service and Engineering Co., Chicago, Ill.

MINNESOTA HYDRO-PLANT WITH SMS TURBINE MODERNIZATION BOOSTS OUTPUT 35%

By completely modernizing a half-century-old horizontal turbine installation having the inside type of gate mechanism, the Upper Midwest's largest utility has raised the potential KWH output over 35%. This resulted from increased plant-efficiency and greater installed capacity. The rebuilding program was a result of careful engineering studies made over several years by SMS in cooperation with the utility and their consultants with whom the purchase of modernized horizontal turbines was finally negotiated.

Four pair of horizontal SMS-Francis wheels with motor operated outside gate mechanisms were mounted on new 9-foot draft chests in the existing 14-foot diameter top supply pressure cases. An additional SMS-Kaplan turbine, rated at 3,500 HP under the 48-foot head, was added to provide flexibility and take load variations at a high efficiency over a wide operating range.

Whether your interest is modernization or a new station, you can rely on the broad engineering background of 80 years' experience available to you at SMS. For information on hydraulic turbines and accessories, write S. Morgan Smith Co., York, Penna.



Performance of modernized units based on index tests run in January 1956. Performance of original units based on guarantees when new.

S. MORGAN SMITH

AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED, TORONTO

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WE MAY SEND MAIL BY ROCKET!

A century from now a wonderful, exciting and different world. But there will be one familiar note. The cast iron pipe laid today will still be carrying water and gas to the homes and industries of tomorrow.

In over 60 American cities, these dependable cast iron water and gas mains, laid more than a century ago, are still serving efficiently. And modernized cast iron pipe, centrifugally cast, is even stronger, tougher, more durable.

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CAST IRON

U. S. PIPE AND FOUNDRY COMPANY, General Office: Birmingham 2, Alabama

A WHOLLY INTEGRATED PRODUCER FROM MINES AND BLAST FURNACES TO FINISHED PIPE.

How long to bridge this 62-foot span . . .

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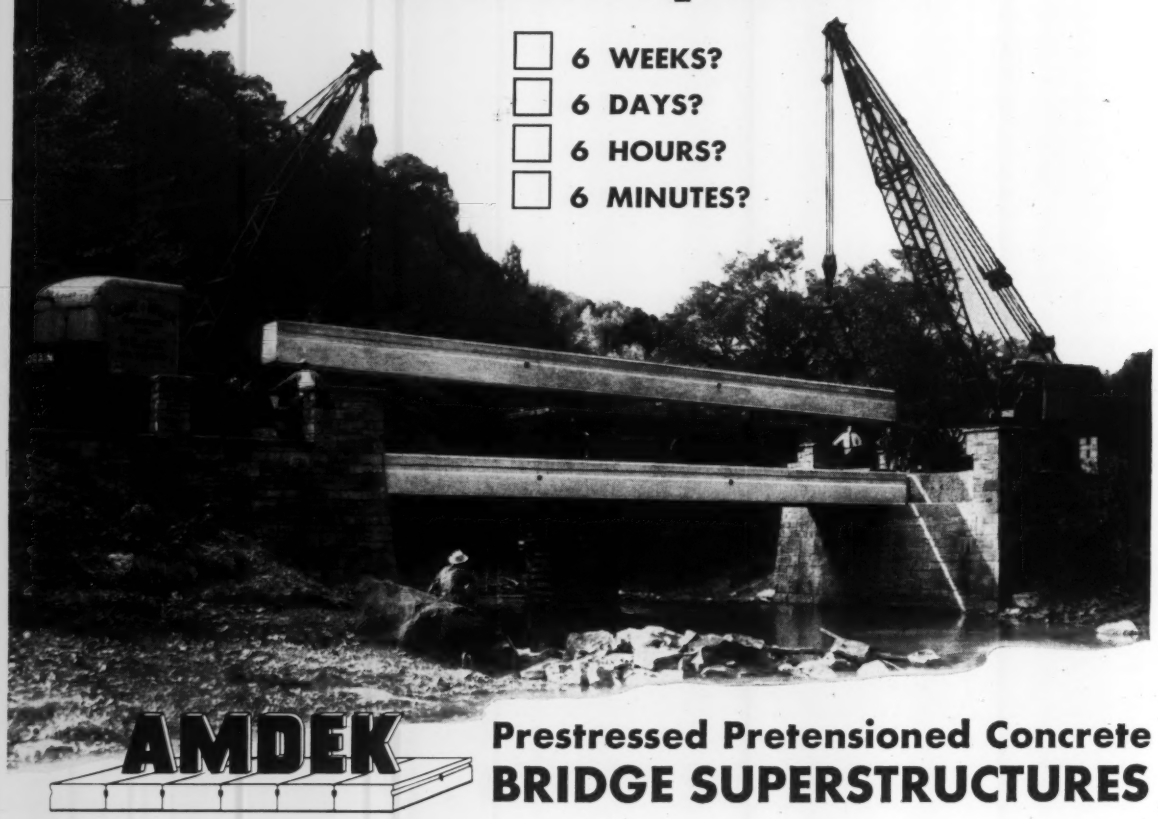
- ☐ 6 DAYS?
- ☐ 6 HOURS?
- ☐ 6 MINUTES?



AMDEK Prestressed Pretensioned Concrete BRIDGE SUPERSTRUCTURES

6 HOURS! That's the remarkably short time it took a few workmen to span Laurelhill Creek near Somerset, Pennsylvania with the longest prestressed bridge in the state. Seven "factory-built" AMDEK sections were swung by cranes into position on offsets built into the old bridge abutments. After a few finishing touches, the bridge was ready for use!

Prestressing, pretensioning and vacuum processing—plus the use of special voids—results in a stronger, lighter bridge member that can be handled by contractors like steel beams—in any weather. You save time, cut costs—build beautiful bridges that give perfect, maintenance-free service for years! Find out more about AMDEK Bridges . . . write for literature and all details.

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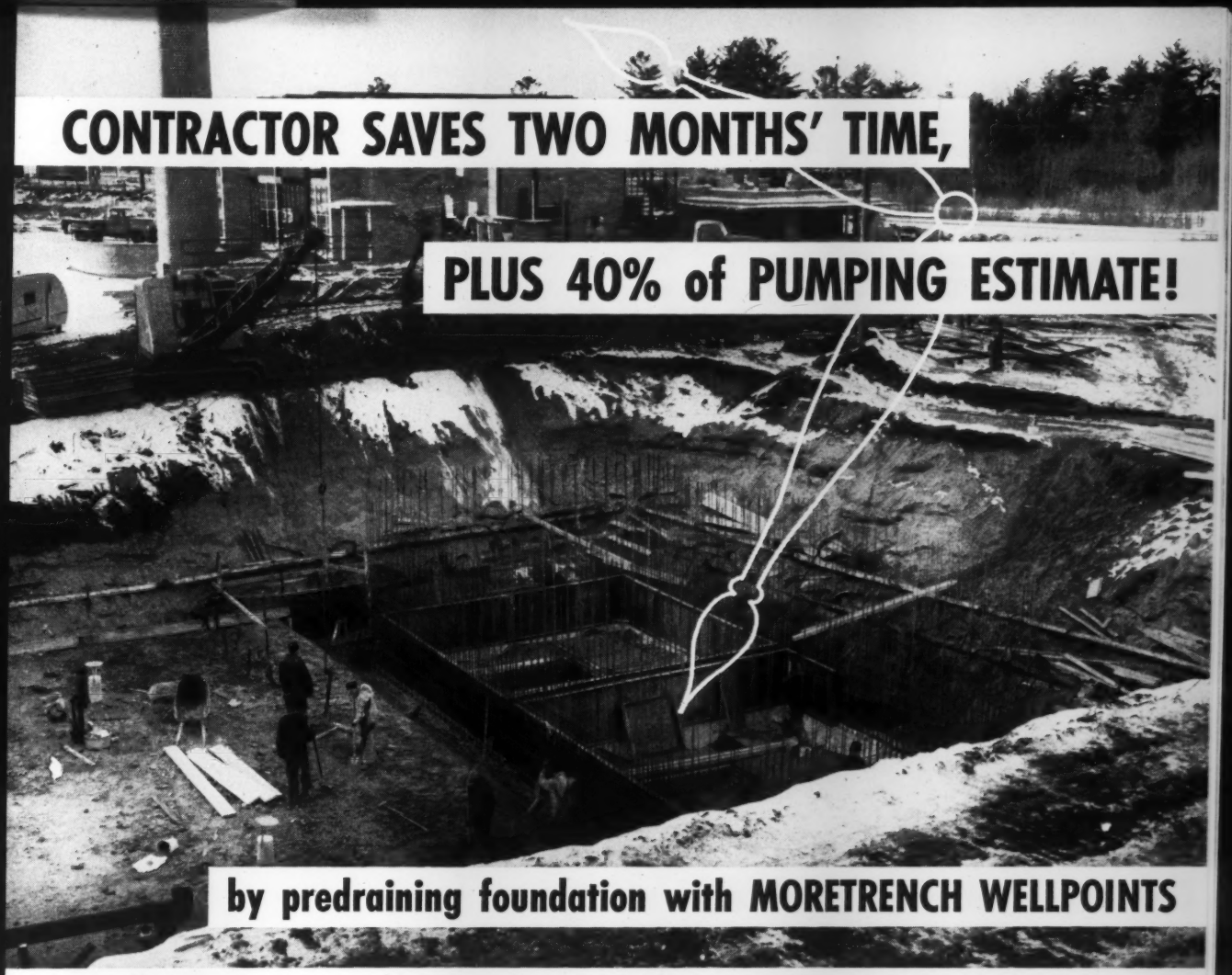
CONTRACTOR SAVES TWO MONTHS' TIME,

PLUS 40% of PUMPING ESTIMATE!



by predraining foundation with MORETRENCH WELLPOINTS

Sewage Treatment Plant, Merrill, Wis. — Contractor: Burger & Vicker, Inc., Wausau

Before ordering pumping equipment for this job, Burger & Vicker, Inc. tested two wellpoints—*in the ground*—Moretrench and another make of wellpoint which they had been using for several years.

The MORETRENCH Wellpoint pumped 25% *more* water than the other.

That did it! Moretrench got the order. Results were immediate—and perfect. 21′ of water disappeared fast.

Here's what the contractor says: "Our pumping estimate on this job was based on our former experience with wellpoints. Using Moretrench, we finished the job *two* months earlier than anticipated at 40% less cost!"

Exceptional? No! For a time and money saver on any wet job, you can't beat a MORETRENCH WELLPOINT SYSTEM. For full details on how to pump—at a profit—contact our nearest office.

MORETRENCH CORPORATION

90 West St. New York 6 | 4900 S. Austin Ave. Chicago 38, Illinois | 7701 Interbay Blvd. Tampa 9, Florida | 315 W. 25th St. Houston 8, Texas | Rockaway New Jersey

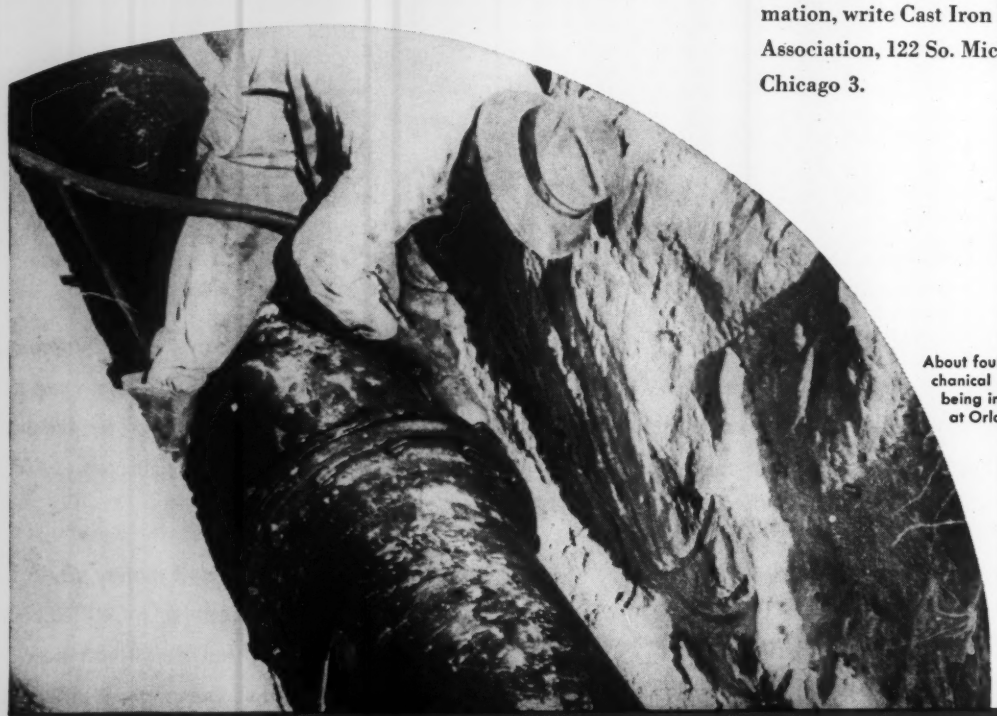
Western Representative: Andrews Machinery of Washington, Inc., Seattle 4, Washington

Canadian Representative: Geo. W. CROTHERS Limited, Toronto, Ontario

When you use it

Installing 6-inch Mechanical Joint cast iron pipe for pressure sewer river crossing to sewage treatment plant at Marquette, Mich.

If you were to put *your own money* in a pipeline that should be as nearly permanent as brains, hands and machines could make it, what pipe would you buy? Cast Iron Pipe, undoubtedly! And why? Because cast iron mains are in their *second century* of service in nearly *seventy* cities. *Modernized* cast iron pipe, as made today, is even tougher and stronger. Since everybody pays taxes, one way or another, everybody benefits when you install long-lived cast iron pipe. For further information, write Cast Iron Pipe Research Association, 122 So. Michigan Avenue, Chicago 3.



About four miles of 16-inch Mechanical Joint cast iron pipe being installed for water line at Orlando, Florida.

CAST IRON PIPE

everybody benefits!

Laying 16-inch cast iron pipe for water line to new Caterpillar Tractor Company plant at Decatur, Illinois.

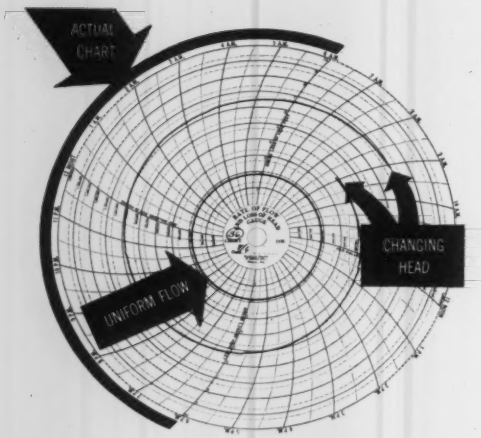
Tieing-in 16" Cement-lined cast iron feeder main with 133-year old cast iron water main in Philadelphia.

Laying 21,000 feet of 6" to 12" cast iron pipe for water main extension at North Brunswick Township, N. J.

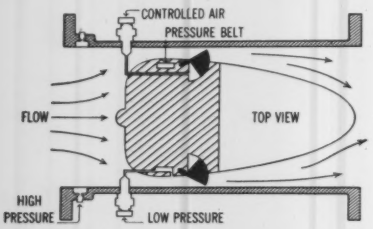
SERVES FOR CENTURIES...

NEW SIMPLEX FILTER RATE CONTROLLER GIVES YOU COMPLETELY PNEUMATIC CONTROL!

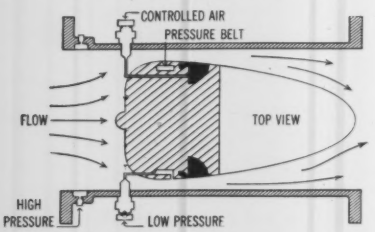
Amazing Modulair® Controller responds fast... closes tight



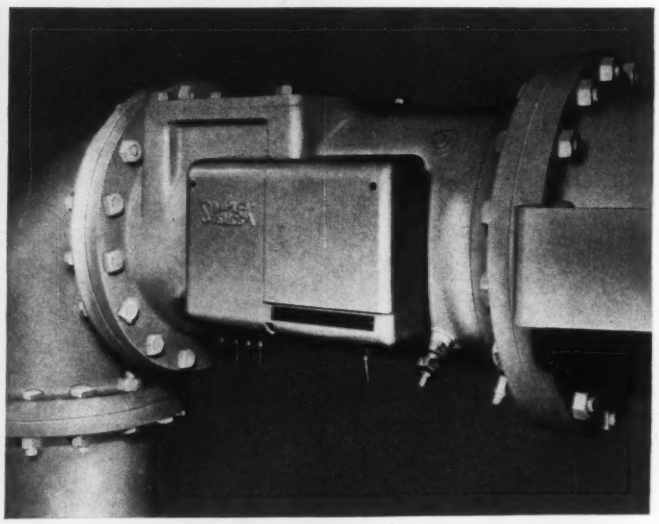
Here's proof that the new Simplex Modulair Filter Rate Controller responds instantly to changes in filter head, holds flow at desired rate . . . automatically! In chart from Modulair installation No. 2, head changes from 4′ to 7′ while rate forms almost perfect circle at the set 275,000 gpd.



How Modulair works! Pipe-like casting with annular Venturi throat houses streamlined inner body with corded-rubber modulator (black) that expands and retracts pneumatically to control flow. When head is low at start of run, modulator expands automatically to hold flow at set rate.



As filter head loss rises, flow tends to decrease . . . and change the Venturi differential. Sensitive Modulair compensates by instantly retracting the pneumatic modulator, maintaining a constant head-loss value through the combined filter and controller, automatically keeping flow at set rate!



Compact . . . easily installed Modulair is only two to three pipe diameters long! It fits wherever a piece of pipe can fit . . . in any position, horizontal or vertical . . . simplifying pipe gallery layout. High-grade, cast iron Modulair comes in 4″ to 24″ standard pipe sizes with corrosion-resisting fittings. Cord-inserted rubber throttling element that's as tough as a truck tire has given 30 years' wear in accelerated life-tests.

Accuracy! In 4 years of field performance, Modulair charts show an accuracy in filter control that exceeds today's most exacting demands. This high degree of control extends for wide ranges of head loss and flow rates, including complete, tight shut-off! And there's no drift at end of run.

Longer filter runs! Modulair combines a low head-loss, annular Venturi measuring element with a streamlined throttling element. This new design offers so little resistance to flow that you get longer filter runs, big savings in wash water!

Minimize maintenance! With Modulair's new design, there's no place for air to accumulate . . . no place for sand to lodge and interfere with accuracy. Throttling element, the only moving part inside pipeline, is non-corrosive rubber. Pneumatic poise element is simple, rugged. There are no line valves, no pilot valves, no pistons, no valve shafts, no stuffing boxes to pack!

Lower first cost! Modulair's low head loss means lower operating head requirements . . . permits vertical compression in plant design and lower costs in plant construction.

Completely pneumatic! No intermediate hydraulic steps! No pilot valves! No hydraulic cylinders! Air loading pressure is applied *directly* to the flow controlling element.

Automatic filter operation! Modulair works with control systems of any type to give you remote rate control or master pneumatic control that's fully automatic.

Technical bulletin! For full details on Modulair, write for Bulletin 950. Simplex Valve & Meter Company, Dept. CV-5, 7 East Orange Street, Lancaster, Penna.

Accurate instruments and controls for over 50 years

SIMPLEX®

VALVE AND METER COMPANY

. . . designed to harmonize with Detroit Technical Center

A special elevated water tank, of outstanding beauty, was erected for an installation north of Detroit. The 250,000-gal. elevated tank having an overall height of 138 ft., was designed, fabricated and erected by Chicago Bridge & Iron Company. Constructed of highly-polished stainless clad steel on the outside it harmonizes with the materials, architecture and landscaping of the Technical Center.

The stainless clad material for the tank required unusual and careful handling during fabrication, shipping and erection to keep the highly polished surface perfectly preserved.

CB&I has complete facilities for designing, fabricating and erecting elevated tanks of standard or unique design. Write our nearest office for further information.

Above: Looking up at the special three column stainless clad Horton® elevated tank. The tank proper is a true ellipse in elevation and is 46 feet in diameter.

CB&I

Chicago Bridge & Iron Company

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
Los Angeles • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • Tulsa

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.

This Armco Sewer has served nearly a half-century and has a life expectancy of many more years.

For long life

Armco Sewer Structures give you both structural and material durability

The 346-ton wheel load of this ladle car has traveled over this 6-foot-diameter Armco Corrugated Metal Pipe several times daily for 29 years.

Armco Corrugated Metal Structures combine both material and structural durability for balanced design. Any sewer structure needs both of these durability features. One without the other is useless. If the sewer fails structurally, your investment is lost no matter how long the material lasts.

Armco corrugated metal construction features high strength with light weight. Bolted connector bands assure strong, tight joints.

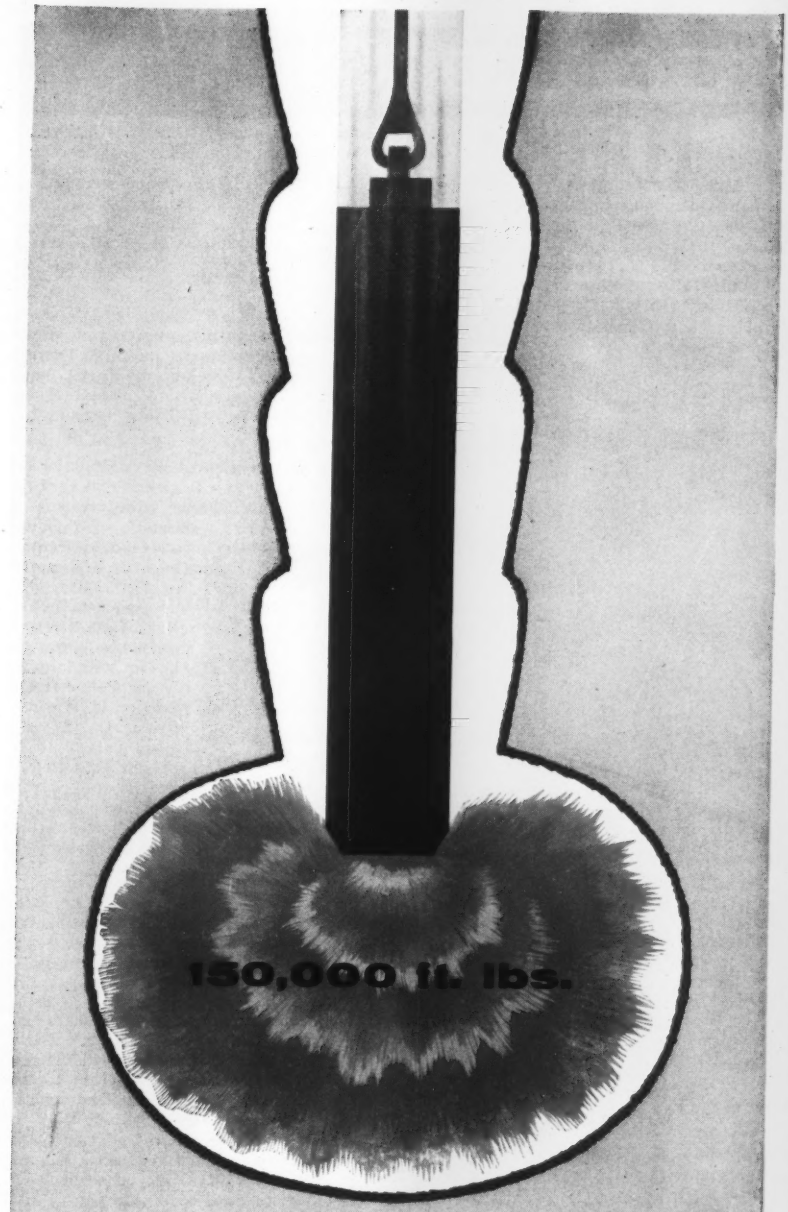
With Armco Structures you can save money by specifying the degree of material durability you need for each condition. Plain galvanized Armco Pipe and Pipe-Arch are ideal for normal service. Armco ASBESTOS-BONDED combats severe corrosive conditions. PAVED-INVERT withstands highly erosive flows. And for lasting top flow capacity, you can specify Armco SMOOTH-FLO Sewer Pipe.

Write for data applied to your specific sewer or drainage projects. Armco Drainage & Metal Products, Inc., 4736 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario. Export: The Armco International Corporation.

ARMCO®

ARMCO

Sewer Structures



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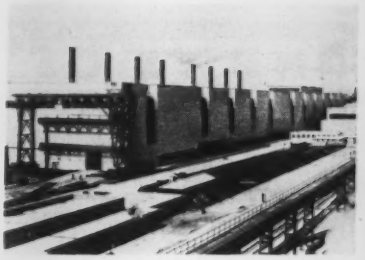

FRANKI FACTS

The following data has been made available by the Franki company of England, one of 31 companies, in 36 countries throughout the world, in the Franki organization.

Client: The Steel Company of Wales Ltd., Abbey Works, Port Talbot, Glamorgan.

Consulting Engineers: W. S. Atkins & Partners, 158 Victoria St., London, S.W. 1, and 199 Bay St., Toronto, Ont.

Type of Structure: New Steel Works.

Number and Length of Displacement Caissons: 32,700 displacement caissons varying between 25 feet and 50 feet.

Working Load: Up to 90 tons.

Soil Conditions: From joint paper of W. S. Atkins & Partners and the General Contractors read before the Institution of Civil Engineers in 1950. "..... a layer of peat up to 15′ in thickness under nearly the whole site..... below it were mixtures of harder clays, gravels and boulders. Solid rock was reached at depths between 50′ and 70′ below ground level."

Job Highlights: To meet the required construction program, W. S. Atkins & Partners decided that the major part of the job was to be carried out by the Franki method. Approximately one displacement caisson in 350 was tested at 150% of the working load with highly satisfactory results. Work commenced in 1947. At one period no fewer than 16 Franki rigs were employed and progress was well maintained.

Franki is presently working on ancillary buildings at the Works.

The Franki displacement caissons on this job carry the largest total load of any individual system of caissons in the world.

LITERATURE AVAILABLE

Brochure describing various Franki Foundation methods will be furnished on request. Write to:

Franki Foundation Company
103 Park Avenue
New York 17, New York

NEWS OF ENGINEERS

John William Graham, Jr., dean of students at Carnegie Institute of Technology, has been appointed vice-president of Cooper Union, effective July 1. Dr. Graham is the first to hold the title of vice-president, a new position created by the trustees to handle an extensive development program, which is expected to include construction of a new engineering school building. Dr. Graham has been on the faculty of Carnegie since 1946.

Leroy W. Heilmann, of Freeburg, Ill., has been appointed deck officer in the U. S. Coast and Geodetic Survey and will be assigned to the ship *Hydrographer*, St. Petersburg, Fla., for hydrographic surveys in the Gulf of Mexico. Mr. Heilmann just received his master's degree in civil engineering from the University of Illinois.

Charles H. Inman was recently appointed director of construction, Tenth Naval District, with headquarters at San Juan, Puerto Rico. Mr. Inman was transferred from Guantanamo Bay, Cuba, where he held the post of special assistant to the resident officer in charge of construction.

Ervin Greenbaum, president of Metallurgical Consultants, Inc.,* of Detroit, Mich., and Colonel in the U. S. Army Reserve, has assumed command of the U. S. Army Reserve School in Detroit.

Frank Tetzlaff, regional engineer for the past five years for Regions I and II of the Public Health Service, Department of Health, Education, and Welfare, covering the ten northeastern states, with headquarters in New York City, has been transferred to the headquarters office of the Public Health Service in Washington, D. C. As chief, Headquarters Engineering Activities, Air Pollution Control Staff, Mr. Tetzlaff will be responsible for technical staff activities and program liaison with other federal agencies in air pollution control.

Frank Tetzlaff

Don E. Johnson recently joined the sales and engineering staff of the J. H. Baxter Company, Portland, Oreg. He was formerly associated with the Mercer Steel Company, of the same city.

Victor Kjellman, for the past ten years field engineer for the Portland Cement Association in the New England area, has joined the staff of the Duracrete Block Co. Inc., at Hooksett, N. H., and will act as consultant and sales manager. His work will consist of promotion, offering engineering service on cement masonry to architects and contractors, and sales.

Henry J. Brunnier, San Francisco, Calif., consulting structural engineer, was named "Outstanding Bay Area Engineer of 1956" at an awards luncheon sponsored by the Bay Area Engineers Week Committee in observance of National Engineers Week in San Francisco. Mr. Brunnier was one of a five-man board of consulting engineers on construction of the San Francisco–Oakland Bay Bridge and is recognized as a top authority on earthquake design and difficult foundation problems.

Marshall B. Crabill was recently made manager of operations of the Indianapolis, (Ind.) Water Co. He has been superintendent of purification since 1948.

Not all vapor trails are made by bombers. Fairchild survey crews often fly at altitudes that leave their mark in the sky.

Why fly so high? The cost of compilation in aerial map making is a function of the number of photographs. Also, more area can be covered per hour, thus reducing flying time. This is important when fighting bad weather, and also results in great savings in time and money.

But precision, high-altitude aerial mapping demands more than high flying airplanes. Special precision camera equipment, and highly developed pilot and cameraman techniques are also vital. And the most important ingredient—experience—nearly 40 years of it, goes into every Fairchild survey.

Reliable Fairchild consultation on your mapping problems is available to you—anytime and without obligation. Call your nearest Fairchild office.

The pioneer in high altitude aerial mapping

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Los Angeles, Calif.: 224 East Eleventh St. • **New York City, N.Y.:** 30 Rockefeller Plaza • **Chicago, Illinois.:** 111 West Washington St. • **Atlanta, Georgia:** 333 Candler Bldg. • **Long Island City, N.Y.:** 21-21 Forty-First Ave. • **Boston, Mass.:** New England Survey Service, Inc., 51 Cornhill • **Seattle, Wash.:** Carl M. Berry, Box 38, Boeing Field

Karl Imhoff, world renowned sanitary engineer and consulting engineer of Essen, Germany, was honored by the Federation of Sewage and Industrial Wastes Associations and other organizations on his 80th birthday on April 7. Other honors were bestowed on Dr. Imhoff at a gathering of German engineers in Bonn on April 9. Dr. Imhoff has devoted his life to improved sanitation through treatment of sewage and industrial wastes. His invention of the Imhoff Tank in 1907 was hailed as a major contribution to the profession.

Joseph H. Moore, consulting engineer on the industrial water supply project at Bushy Park, S. C., has opened consulting offices at Charleston and Moncks Corner, S. C. He recently completed an assignment with the Harza Engineering Company in Jordan, where he was manager on the Yarmouk-Jordan Valley project.

George J. Kral, civil engineer of Finneytown, Ohio, announces the formation of the engineering and architectural firm of Morrell, Kral and Zepf, with offices in the Ingalls Building, 6 East Fourth St., Cincinnati, Ohio. The firm will specialize in the design of industrial and commercial buildings and schools and in site development.

Austin Campbell Newman, civil engineer of Westfield, N. J., has joined the staff of the Esso Research and Engineering Company's mechanical division. Mr. Newman was formerly assistant engineer with the Lock Joint Pipe Company, Wharton, N. J.

Harry W. Dennis, former Vice-President and Director of ASCE and former chief civil engineer of the Southern California Edison Co., is the author of a novel, *Mighty Waters,* published by Vantage Press, Inc. (120 West 31st Street, New York 1). The publisher calls the book "a vivid human picture of men at work... refashioning the face of nature to build great things for California's future." Mr. Dennis is now living at 2619 Wilshire Blvd., Los Angeles 57, Calif.

Robert E. Gosa has been appointed executive vice-president of Williams-McWilliams Industries, Inc., of New Orleans, La. He will be in charge of the W. Horace Williams Division, which resulted from a recent merger of that company with the McWilliams Dredging Company of New Orleans. Mr. Gosa has been president of the W. Horace Williams Co. for five years and has been connected with the design, engineering, and construction industry since 1920.

Robert E. Gosa

Charles C. Zollman has opened a consulting engineering office, specializing in precast and prestressed concrete, at 101

(*Continued on page 22*)

The man behind the gun will tell you . . .

WHITE GIVES YOU greater, longer-lasting precision–

Shown, model 7014 with "A" standard. Sold complete with tripod case and field equipment. Model 7014 same unit with "U" standard, also available.

...yet costs less than other quality engineers' transits

LIKE every White quality-built instrument, these engineers' transits give you greater dollar-for-dollar value than any other comparable unit.

For example: White uses a recently-developed Swiss Dividing Engine to cut graduations into solid silver. This insures super-precision from the beginning, safeguards it through more years of hard field usage.

In addition, White engineers' transits give you internal focusing, covered leveling screws, and coated optics. These and a host of other design and operating features combine to give you a transit unsurpassed for ease, speed, accuracy, economy and long-lived dependability. Write for Bulletin 556 and the name of your nearest dealer. DAVID WHITE COMPANY, 309 W. Court Street, Milwaukee 12, Wisconsin.

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Even at long distances under adverse weather conditions, you get a clear, sharp image — without halation.

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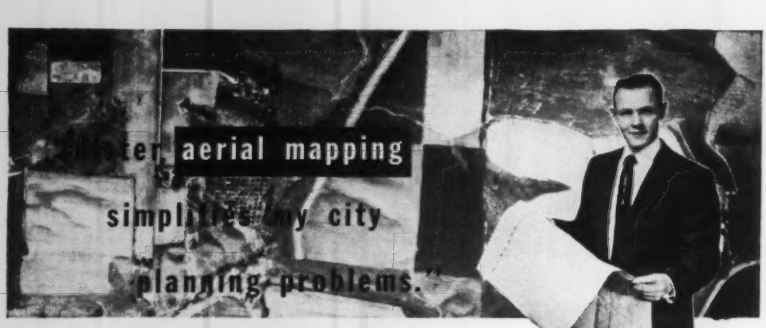

—**BURL A. PARKS** City Planning Engineer, Davenport, Iowa

"Planning the extension of our street system beyond corporate limits would have been impossible without the topographical maps Alster & Associates made for us from aerial photography," writes Davenport's City Planning Engineer. "The maps of fringe areas make it simple to choose best locations for street grades, drainage, and sewer extensions and to examine proposed land subdivisions." *Learn how Alster mapping can simplify your survey problems.*

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DIVISION OF H. K. PORTER COMPANY, INC. **HKP**

News of Engineers

(*Continued from page 21*)

Gleaves Road, Springfield, Pa. Mr. Zollman has been chief engineer of Vacuum Concrete, Inc., since 1951, engaged in all precasting and prestressing phases of concrete construction. He developed the precast concrete thin shell roof panels currently in use on several large military warehouse projects.

Boris W. Boguslavsky has left Georgia Institute of Technology, where he was professor in charge of structural design in the School of Architecture. Dr. Boguslavsky is now senior civil engineer with the Aramco Overseas Co. in the Netherlands. His address is Laan van Meerdervoort 55, The Hague, Netherlands.

Ammann & Whitney, consulting engineers of New York City, announce the appointment of **Edward Cohen, Benjamin Forsyth, Robert H. Goldsmith,** and **Russell C. Hertzler, Jr.,** as associates in the firm.

Eldon V. Hunt has resigned as chief engineer of the Alberta Gas Trunk Line Co., of Calgary, Alberta, and moved to New York city to join the staff of Ebasco Services, Inc., as assistant construction manager in charge of pipeline and related activities throughout the country. Mr. Hunt has been with Ebasco before in the capacity of construction superintendent. He went to Canada in 1954.

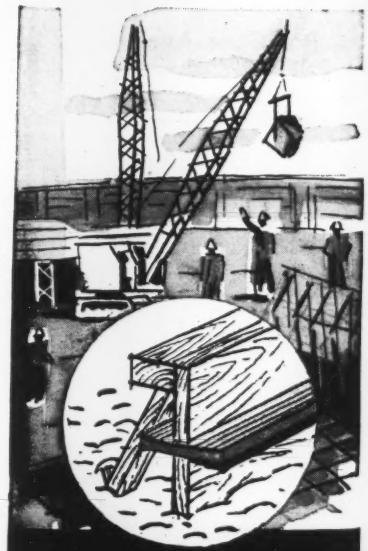
Eldon V. Hunt

Daniel J. Weiner recently rejoined the staff of Haskins, Riddle and Sharp of Kansas City, Mo., after a two-year tour of duty with the U. S. Public Health Service in Indo-China, where he was stationed at Saigon. In his association with the Kansas City consulting firm Mr. Weiner will be identified with general sanitary and hydraulic design and will specialize in industrial waste treatment.

Harry E. Bovay, Jr., consulting engineers of Houston and Spokane, Wash., announce the removal of their Northwest office to larger quarters at 933 West Third Avenue, Spokane 4.

Walter L. Huber, Past-President of ASCE and prominent San Francisco consultant, was recently elected chairman of the Interior Department's Advisory Board on National Parks, Historic Sites, Buildings and Monuments. Mr. Huber has been a member of the Advisory Board since June 1953.

Richard F. Wittenmyer has been appointed associate research director of the Austin Company, national engineering and construction firm of Cleveland, Ohio. He has been a member of the Austin research staff since 1946.



NEW! FLEXTRIP WATERSTOP

THE LATEST

VINYL PLASTIC WATERSTOP

for "wall-floor" and "between-pour" horizontal concrete construction joints

Water just can't get through joints protected by FLEXTRIP, the all-new, strip-type waterstop. Unique concave shape plus ribbed edges give FLEXTRIP a never ending grip in the concrete . . . is flexible enough to withstand extreme joint-separation (more than 3 inches) yet rigid enough to stand up to the battering effect of pouring concrete. Here's lasting joint-protection unmatched by any other waterstop. What's more, FLEXTRIP will never rust, rot, check or crack and is unaffected by acid, alkalies, petroleum products, chemicals or the most adverse atmospheric conditions . . . lasts as long as the concrete. Write for additional information on FLEXTRIP and other vinyl waterstops. Send coupon below.

Made by the makers of LABYRINTH WATERSTOPS . . . the standard waterseal on outstanding construction jobs everywhere — eliminates seepage problems . . . simplifies form work.

Made in Canada for J. E. Goodman Sales Ltd. Toronto, Ontario

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Without obligation, please send me information on your new FLEXTRIP and LABYRINTH WATERSTOPS.

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Company_____

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City_____ Zone____ State____

Louis V. Migone, consulting engineer, Buenos Aires, Argentina, has been named president of the National Commission of Housing by the new Government of Argentina. Public housing is recognized as one of the biggest and most serious problems facing the post-Peron administration. Mr. Migone is well and favorably known among engineers of the Western Hemisphere and Europe as a leading proponent of international cooperation and organization among national engineering societies. He has been active in the affairs of USAI (Union of South American Engineering Societies) and was one of the founding fathers of UPADI (Federation of Pan American Engineering Societies). As chairman of UPADI's first Committee on Engineering Ethics, Mr. Migone provided the leadership which resulted in the first Code of Engineering Ethics concurred in by practically all the national engineering societies of the Western Hemisphere.

Frederick S. Adams has accepted a position as district engineer for the American Institute of Steel Construction, New York, N. Y. For the past six years Mr. Adams has been chief engineer for Industrial Steel, Inc., of Albuquerque, N. Mex.

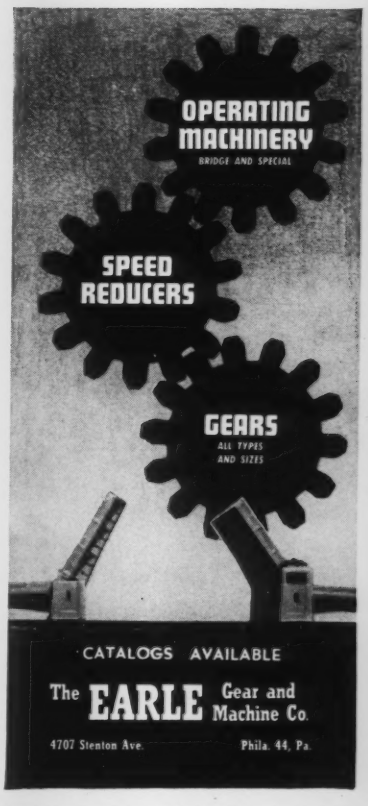
Richard A. Haber has assumed the combined duties of chief engineer of the Delaware State Highway Department and the Delaware Interstate Highways Division (toll). He was previously chief engineer of the Department, but during the past two and one-half years has been associated with Michael Baker, Jr., Inc., of Rochester, Pa., as vice-president and executive engineer.

Richard A. Haber

Ervin L. Knebes retired on March 1 as assistant engineer of Milwaukee, Wis. Mr. Knebes has been with the City of Milwaukee since 1912, and has been assistant city engineer since 1923. He will be succeeded by **Eugene A. Schmidt,** formerly engineer in charge of the Engineering Division, Bureau of Engineers. Mr. Schmidt has been with the city for over 30 years.

Ferdinand Leiser, co-founder and president of Christie and Leiser Inc., building contractors, has been elected a vice-president of Kuhn, Smith and Harris, Inc., New York building firm. Mr. Leiser will take charge of the company's industrial construction program. His former company was dissolved upon the retirement of his partner.

Fred O. Francis was elected vice-president of the John W. Cowper Company, Inc., Buffalo, N. Y., at a directors' meeting on March 13. With the company since 1936, Mr. Francis has been a director and chief engineer for several years.



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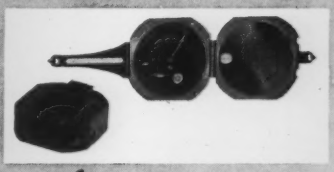

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- Used in hand or on tripod.
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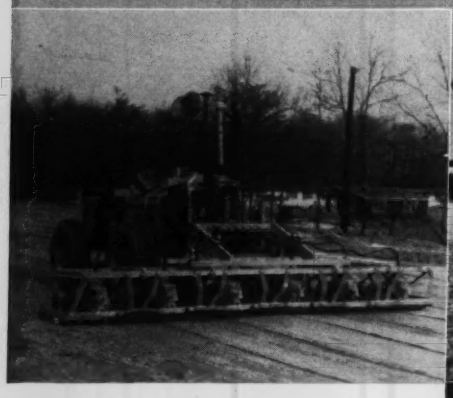
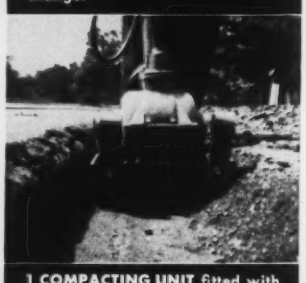


6 COMPACTING UNITS IN WORKHEAD for maximum productivity in straight-away work. Left: Compacting sand fill in a bridge approach . . . another phase of its wide range utility to paving contractors.

4 COMPACTING UNITS just fit this widening job-change required in only a few minutes.

Plus UNMATCHED ON-THE-JOB *ADAPTABILITY!*

3 COMPACTING UNITS in tandem and staggered, suits this job ideally — a quick and easy change.



1 COMPACTING UNIT fitted with operating handle and narrow base. Just right for the otherwise unreachable spots.

2 COMPACTING UNITS in twin hook-up — self-propelling. One man readily compacts up to 4000 sq. ft. per hr. in 10" layers.

For consolidating granular soil sub-bases and the base courses of sand, gravel, rock or slag in waterbound and penetration macadam construction, there is just nothing that compares with the Jackson Vibratory Multiple Compactor. It not only does the straight-away work in only half the time required by equipment of other types, but is so versatile, so easily adaptable on the job that it can be used to great advantage for widening projects of any width and getting into places other equipment can not touch. As may be noted in the illustrations, any number of compacting units may be used in the workhead (up to 6, which covers 13′, 3″) to exactly fit the job at hand. Units may be towed at the side or fitted with operating handles and used as individual, self-propelling compactors. Quickly interchangeable bases from 12″ to 26″ are also available for compacting in trenches, etc.

For compacting granular soil fills of all kinds, the Jackson Multiple Compactor is a terrific cost saver and progress expediter. *It's the predominant medium of consolidation used on the outstanding paving jobs in the country today.* See your Jackson distributor for complete details. We will gladly furnish his name, and literature, on request.

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Positions Announced

Army Corps of Engineers. The Mobile District needs immediately fifteen engineers and one architect for work in the design, structural, mechanical, electrical, and civil branches who can design facilities for the Army and the Air Force and for water resources development. Hydraulic and general engineers are also needed. More information from the Mobile Engineer District, 2301 Grant Street, Mobile, Ala.

Army Corps of Engineers. The Philadelphia District needs immediately permanent civilian engineer employees in the Civil, Geological, Structural and other branches. Salaries range from $4,930 to $7,570 per year. Engineers are also being recruited for overseas employment in all parts of the world at salaries ranging up to $7,570 per year plus 25 percent for overseas service. Further information from the Personnel Branch, Philadelphia District, U. S. Corps of Engineers, P.O. Box 8629, Philadelphia 1.

New York State Department of Public Works. There are vacancies for 14 Assistant Civil Engineers (Design) in Albany. A State civil service examination to fill the positions will be held June 23. Appointments will be made at $5,660 with five annual salary increases to $6,940. Eligible candidates must have a master's degree in civil engineering and one year of experience or a bachelor's degree and two years' experience. High school graduates may qualify with six years of appropriate experience. Applications will be accepted to May 25. Information and applications from Recruitment Unit, New York Department of Civil Service, Albany, N.Y.

State College of Washington. The Department of Civil Engineering at the State College of Washington, Pullman, Wash., has several Research Assistantships available in Hydraulic and Sanitary Engineering, as well as Teaching Assistantships in Civil Engineering. These call for half-time service, and the degree of master of science in hydraulic engineering, sanitary engineering, or civil engineering may normally be obtained in two years. Salary is $1,400 for the first academic year, and $1,490 for the second. Summer work is generally available. Further information from Emmett B. Moore, Chairman, Department of Civil Engineering, State College of Washington, Pullman, Wash.

U. S. Patent Office. Engineers and scientists are needed immediately as Patent Examiners by the U. S. Patent Office, Washington, D. C., to pass upon applications for patents in a wide range of technical fields. Salaries from $4,345 to $7,570. Vacations and sick leave and pension benefits are liberal. The positions call for a college degree in engineering or applied science or a college degree with a major in chemistry or physics or with certain combined credits in these fields. Further information from the Commissioner of Patents, Washington 25, D. C.

U. S. Navy. Overseas opportunities for graduate engineers with the Navy in Guam (18 months) and Hawaii (24 months) as Junior Engineers in Civil, Construction, Sanitary and other branches. Salaries are $3,670 a year plus a 25 percent territorial post differential on Guam and a 20 percent cost-of-living allowance in Hawaii. Transportation overseas and return is provided with travel in a pay status. Transportation provided for family when authorized. Obtain a Standard Form 57 from your Post Office, State Employment Service office, or campus student placement office. Fill out and send to Navy Overseas Employment Office (Pacific), 45 Hyde Street, San Francisco 2, Calif.

RECENT BOOKS

Concrete Materials and Practice

This is a broad outline by L. J. Murdock, of the science of concrete making, emphasizing practical applications. Properties, basic materials, and techniques of making concrete under various conditions and for various purposes are treated in detail. Methods of testing, mix design, and quality control on the site are also discussed. New chapters on admixtures and on some of the more practical aspects of prestressed concrete have been added to this edition. (Edward Arnold Publishers Ltd., St. Martin's Press, 103 Park Ave., New York 17, N.Y., 1955. 367 pp., $8.50.)

Handbook of Fastening and Joining of Metal Parts

The aim of this large volume has been to provide the design engineer with a reference and an idea source covering all known methods of joining metal parts. The first section covers fundamentals of the various fasteners and fastening techniques: screws, bolts, and nuts; locking nuts; design of screw fastenings; riveting; welding; brazing and soldering; adhesive; bonded joints; couplings; clamps; snap slides; and others. The authors are V. H. Laughner and A. D. Hargan. (McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N.Y., 1956. 622 pp., $15.00.)

Hydraulic Institute Standards

These standards provide up-to-date information on the classification, nomenclature, applications, rating, testing, installation, operation, and maintenance of reciprocating, rotary, and centrifugal pumps, along with data on friction loss for water and viscous liquids, pipe dimensions, properties of water, viscosity of common liquids, and materials of construction for pumping various liquids. (Hydraulic Institute, 122 East 42nd St., New York 17, N.Y., 1955. $4.75.)

Idées Actuelles sur la Technologie du Béton

A survey by Robert L'Hermite, of the research approach as applied to the important characteristics of concrete. The five main sections cover the following: composition, mixing, transport, and general conditions of use; shrinkage and plasticity; breaking strength under various forces and conditions; hardening time, hydraulic aspects, etc.; brief treatment of quality control and non-destructive testing. (Institut Technique du Batiment et des Travaux Publics, Paris, 1955. 252 pp., F frs. 2000.)

Materials Handbook

This standard reference volume by George S. Brady, gives information on the general characteristics, sources, and uses of metals, refractories, fibers, woods, plastics, and other classes of raw and processed materials used in industry. This edition, enlarged by about one-hundred pages, covers approximately 10,000 materials. (McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N.Y. 1022 pp., $11.00.)

Nouveaux Complements d'Hydraulique Part II

L. Escande is the author of a collection of summaries of researches in the hydraulics field during 1953 and 1954. Representative topics are as follows: dam design; water intake through a grill; hydraulic models and similitude tests; wake of a cylinder in transient flow; surge chamber studies (several chapters); overpressure effects and cavitation under various conditions. (Publications Scientifiques et Techniques, No. 302, du Ministere de l'Air, Paris. 274 pp., F frs. 2400.)

Plastics Progress 1955

Papers and Discussions at the British Plastics Convention, 1955.

Recent developments in many fields of plastics technology are covered in papers grouped under the following headings: polymer structure and properties; expanded plastics; thermoplastics; extrusion; work study and productivity; injection molding; patents; foundry resins; and glass reinforced plastics. Edited by Phillip Morgan. (Philosophical Library, Inc., 15 East 40th St., New York 16, N.Y., 1955. 432 pp., $17.50.)

Soil Physics

A clear and readable treatment by L. D. Baver, of both the fundamentals and applied aspects of this basic subject. The book emphasizes recent developments in the field starting with the basic make-up of the soil and continuing with the physical properties of the various soil components. There are two entirely new chapters on irrigation and drainage, and major additions have been made to the material on soil puddlability, soil conditioners, diffusion processes, hydraulic conductivity, soil moisture stress, and wind erosion. (John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1956. 489 pp., $7.75.)

Surveying for Civil Engineers

This book, by Philip Kissam, deals with the equipment, techniques, and procedures for projects which, because of their large size, permanence, importance, or need for high accuracy, require precise measurements, efficient methods, or special operations. Extensive coverage is given to new types of instruments and methods, and separate chapters are devoted to the various operations, including boundary, public land, city, mine, hydrographic, bridge, and tunnel surveying. Also covered are rigorous methods for net adjustments, aerial mapping and, in the appendix, probability, least square, and the theory of state coordinate systems. (McGraw-Hill Book Company, 330 West 42nd St., New York 36. 716 pp., bound. $8.50.)

Traffic Engineering

The subjects dealt with include the characteristics of traffic (road users, vehicles, speed, volume, intersections, accidents, etc.); regulations; control devices such as signs, signals, and lighting; design; and administration and planning. Both the design of parking terminals and planning for off-street parking are covered. The book is intended as a text for traffic engineering training and a reference for those engaged in traffic planning, operation, and administration. The authors are T. M. Matson, W. S. Smith, and F. W. Hurd. (McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N.Y., 1955. 647 pp., $12.50.)

Unistrut Space-Frame System

This is a report, in two sections, on the technical development and testing program of a structural framing system which can be used for both roof and floor construction. The first section describes in detail the laboratory tests and gravity-load and lateral-load field tests conducted, and gives an analysis of the field-test findings. The second section consists of illustrations showing the history of the research and of a series of charts interpreting graphically the various tests that were made. The authors are Paul H. Coy and Leo M. Legatski. (University of Michigan Press, Ann Arbor, Michigan, spiral binding, $7.50.)

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WET JOBS

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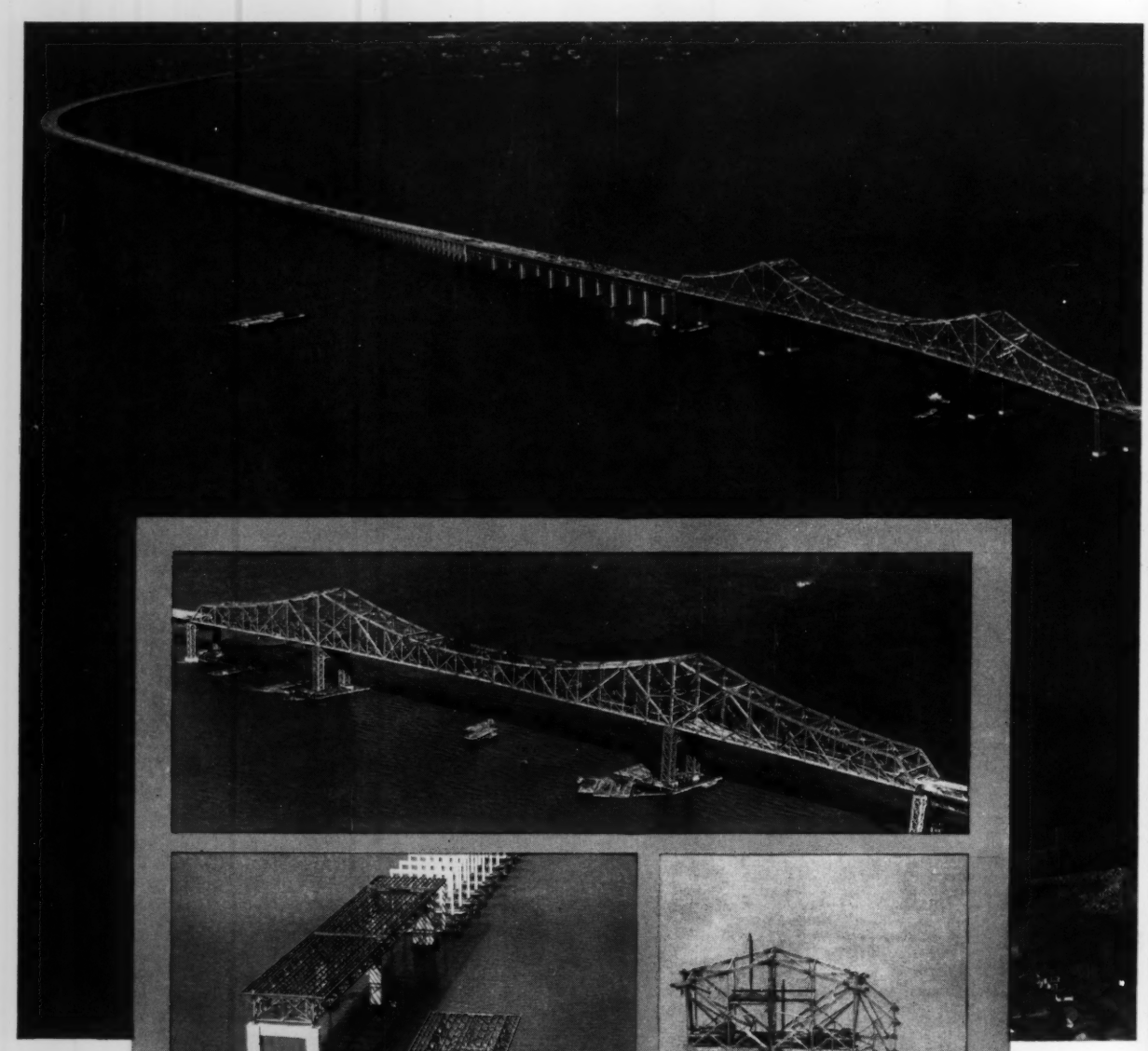
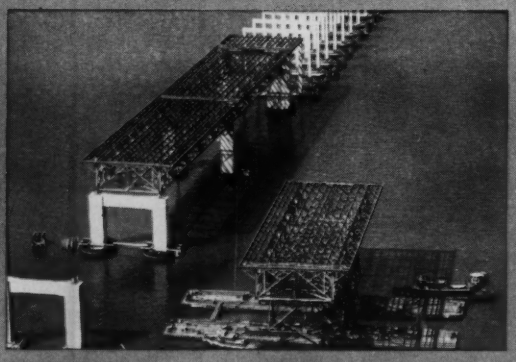
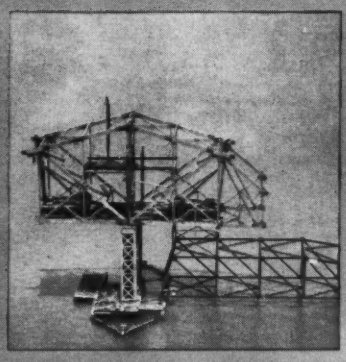
16,000 FT. TAPPAN ZEE BRIDGE



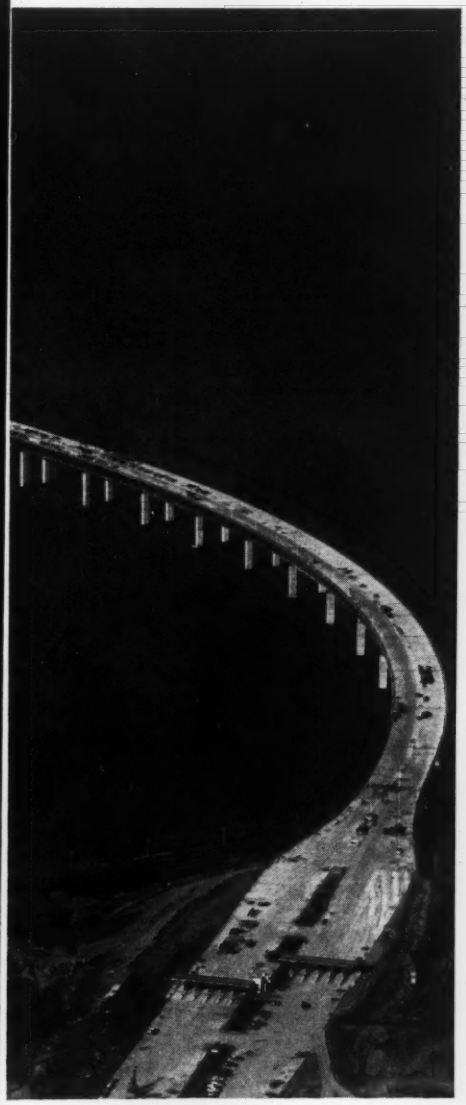




DESIGNED BY:
New York State Thruway Authority. Madigan-Hyland, Consulting Engineers, Long Island City, N. Y.

FABRICATED AND ERECTED BY:
American Bridge Division, United States Steel Corporation—Years 1953–1955.

HAS HEAVIEST CANTILEVER IN THE U.S.



Another BIG one
Fabricated and Erected by
AMERICAN BRIDGE

Spanning the Tappan Zee of the Hudson River between South Nyack and Tarrytown, this 16,000′ long structure is the longest bridge on the New York Thruway. Containing 58,600 tons of structural steel, it is also one of the biggest projects of its type ever undertaken in the United States. An interesting sidelight on the enormity of the project is the fact that its construction required an additional 6,820 tons of structural steel for special erection material.

The long bridge consists of a 10,127′ west approach made up of seven Deck Truss Spans about 247′ long, one Deck Plate Girder Span 100′ long, and one hundred and sixty-five Deck Beam Spans about 50′ long; the main structure over main navigation channel made up of one Thru Cantilever-and-Suspended Truss Span 1,212′ long and two Thru Truss Anchor Spans 601′-9″ long; and a 3,457′ east approach made up of thirteen Deck Truss Spans measuring 232′ to 247′ in length and seven Deck Beam Spans about 55′ long.

The 30,460-ton main cantilever truss structure is the heaviest of its type in the United States and the third heaviest in the world. Its total length, as well as the length of the main span, is the second longest in this country, and fifth longest in the world. Trusses are 93′ apart, center to center, and the 90-ft. deck carries two 37′ roadways for six lanes of traffic, a 10′ center mall for disabled cars, and two 3′ safety walks. Vertical clearance under the main span is 135′ above mean low tide.

The erection of the huge $60,000,000 structure presented many interesting problems. For example, nineteen of the deck truss spans were assembled at Grassy Point on 16-story-high falsework and floated into position atop the piers 12 miles down the river. Because of the great depth to firm foundation in the river bed, it was impractical to erect the anchor spans of the cantilever structure by means of conventional falsework. Instead, two special falsework truss spans were used, one under each anchor span. These were also constructed at Grassy Point and floated to the site. If you are interested in receiving a more complete story of how this was accomplished, write to our Pittsburgh office.

The Tappan Zee crossing is one of 75 New York Thruway bridges, totaling 90,000 tons of steel and over 6 miles of bridgework, between Rochester and the Hudson River, fabricated by American Bridge. American Bridge also erected 48 of these bridges.

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UNITED STATES STEEL

Non-ASCE Meetings

Air Pollution Control Association. Forty-ninth annual meeting, Hotel Statler, Buffalo, N. Y., May 20–24. Information from Thomas H. Trimble, Public Relations Director, Box 344, Niagara Falls, N. Y.

American Society for Testing Materials. Fifty-ninth annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J., June 17–22. Information from ASTM, 1916 Race Street, Philadelphia 3, Pa.

Building Research Institute. Fifth annual meeting, Sheraton-Brock Hotel, Niagara Falls, Ontario, May 20–22. Information from Building Research Institute, 2101 Constitution Avenue, Washington 25, D. C.

Concrete Reinforcing Steel Institute. Annual meeting, The Greenbrier, White Sulphur Springs, W. Va., May 28–June 2. Information from H. C. Delzell, Managing Director, Concrete Reinforcing Steel Institute, 38 South Dearborn Street, Chicago 3, Ill.

International Electro-Technical Commission. International conference on large electric systems, 16th International Conference, Paris, France, May 30–June 9. Further in formation from Philip Sporn, 30 Church Street, New York City, N. Y.

Materials Handling Training Conference. Third annual conference, Lake Placid, N. Y., June 17–30. Information from James R. Bright, Director, MHTS Lexington, Mass.

National Society of Professional Engineers. Annual meeting at the Ambassador Hotel, Atlantic City, N. J., May 23–26. Information from NSPE, 2029 K Street, N. W., Washington 6, D. C.

Prestressed Concrete Institute. Second annual convention, Hollywood Beach Hotel, Hollywood, Fla., May 16–18. Information from Prestressed Concrete Institute, P. O. Box 495, Lakeland, Fla.

The President's Conference on Occupational Safety. 1956 Conference on job-safety in construction, Washington, D. C., May 14–16. Opening session on May 14 in Constitution Hall, 18th and D Streets, N. W. All other sessions in the Departmental Auditorium, Constitution Ave. with the exception of Tuesday morning when concurrent sessions will be held in the Department of Agriculture and Department of Commerce Auditoriums. Reservations to be made directly to the Mayflower Hotel, Connecticut Ave. and DeSales St., Washington 6, D. C.

Society of Automotive Engineers. Summer meeting, Chalfonte-Haddon Hall, Atlantic City, N. J., June 3–8. Information from SAE, 29 West 39th Street, New York 18, N. Y.

Society for Advancement of Management. First National Material Handling Conference, Hotel Statler, New York City, May 17–18. Information from S. A. M., 74 Fifth Avenue, New York 11, N. Y.

University of California. World Conference on Earthquake Engineering, University of California campus, Berkeley, Calif., June 12–16. Information from Department of Conferences and Special Activities, University Extension, University of California, Berkeley 4, Calif.

Wire Reinforcement Institute. Annual Spring Meeting, Greenbrier Hotel, White Sulphur Springs, W. Va., May 28–30. Information from Don Gehring, Wire Reinforcement Institute, National Press Building, Washington 4, D. C.

World Power Conference. Fifth World Power Conference, Vienna, Austria, June 17–23. Further information from U. S. National Committee, Stewart E. Reimel, Secy., c/o Engineers Joint Council, 29 W. 39th Street, New York 18, N. Y.

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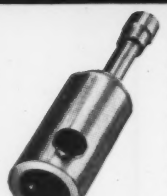

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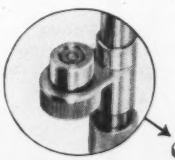

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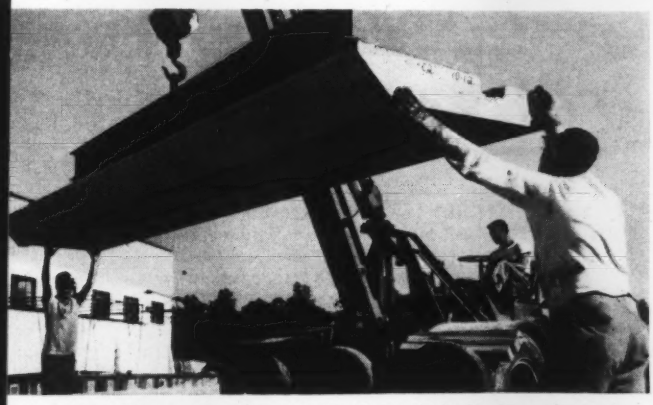
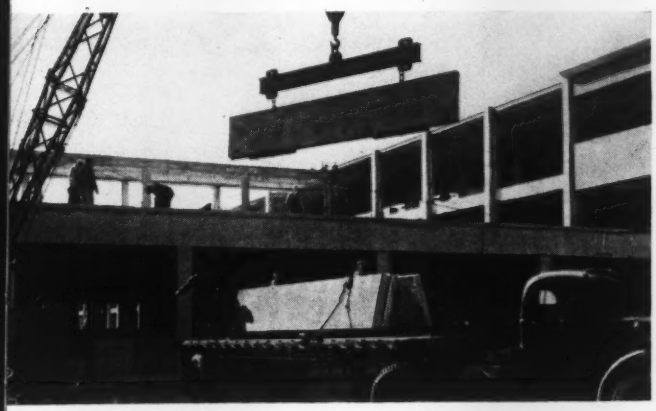
▲ Removing panel from form just one day after being poured . . . ⅓ the usual time. Wall panels vary in size from 2′ 2″ x 2′ 3″ to 18′ 5″ x 6′ 6″.



▲ In addition to the wall panels, the job required 260 pieces of precast coping . . . also made with Lehigh Early Strength Cement. The average piece is 3′ wide x 18′ long x 12″ thick.



▲ Wall panels being erected at job site. An exposed aggregate finish was placed on the surface for architectural effect after panels were removed from forms.

PRECAST CONCRETE PANELS

made with

Lehigh Early Strength Cement

FOR WORLD'S LARGEST BUILDING OF CONCRETE PANEL CONSTRUCTION

The use of Lehigh Early Strength Cement in the precast wall panels and coping for the National Security Administration Building at Fort Meade, Md., permitted form removal in ⅓ the usual time—cut form costs by ⅔. This, the world's largest building of concrete panel construction, offers further proof that somewhere on nearly every job Lehigh Early Strength Cement will save time and money.

Manufacturer of precast insulated panels—Marietta Concrete Corp., Rossville, Md.; General Contractor—a joint venture consisting of Chas. H. Tompkins Co., Washington, D.C. and J. A. Jones Construction Co., Charlotte, N. C.; Ready Mix Concrete for panels supplied by Harry T. Campbell Sons Corp., Towson, Md.; Supervision by U.S. Army Corps of Engineers.

LEHIGH PORTLAND CEMENT COMPANY

Allentown, Pa.

- **Lehigh Early Strength Cement**
- **Lehigh Portland Cement**
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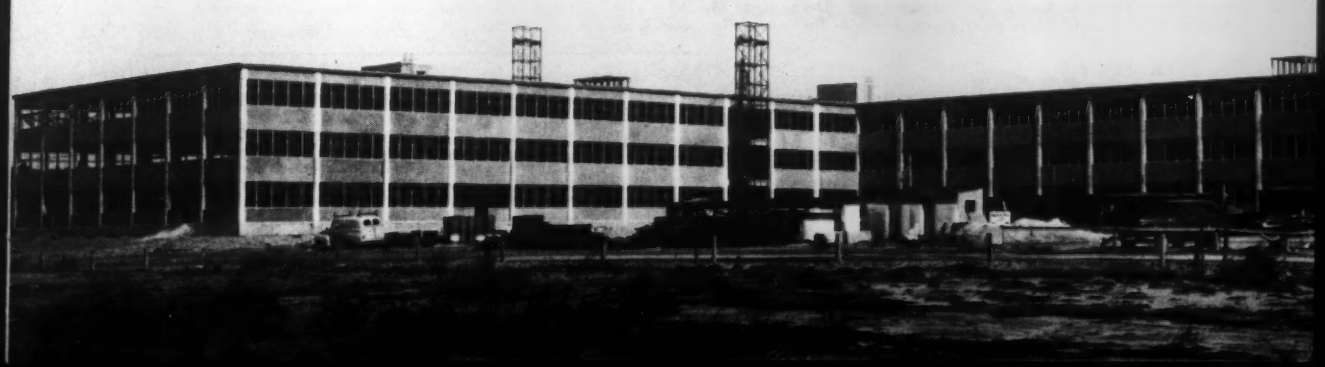
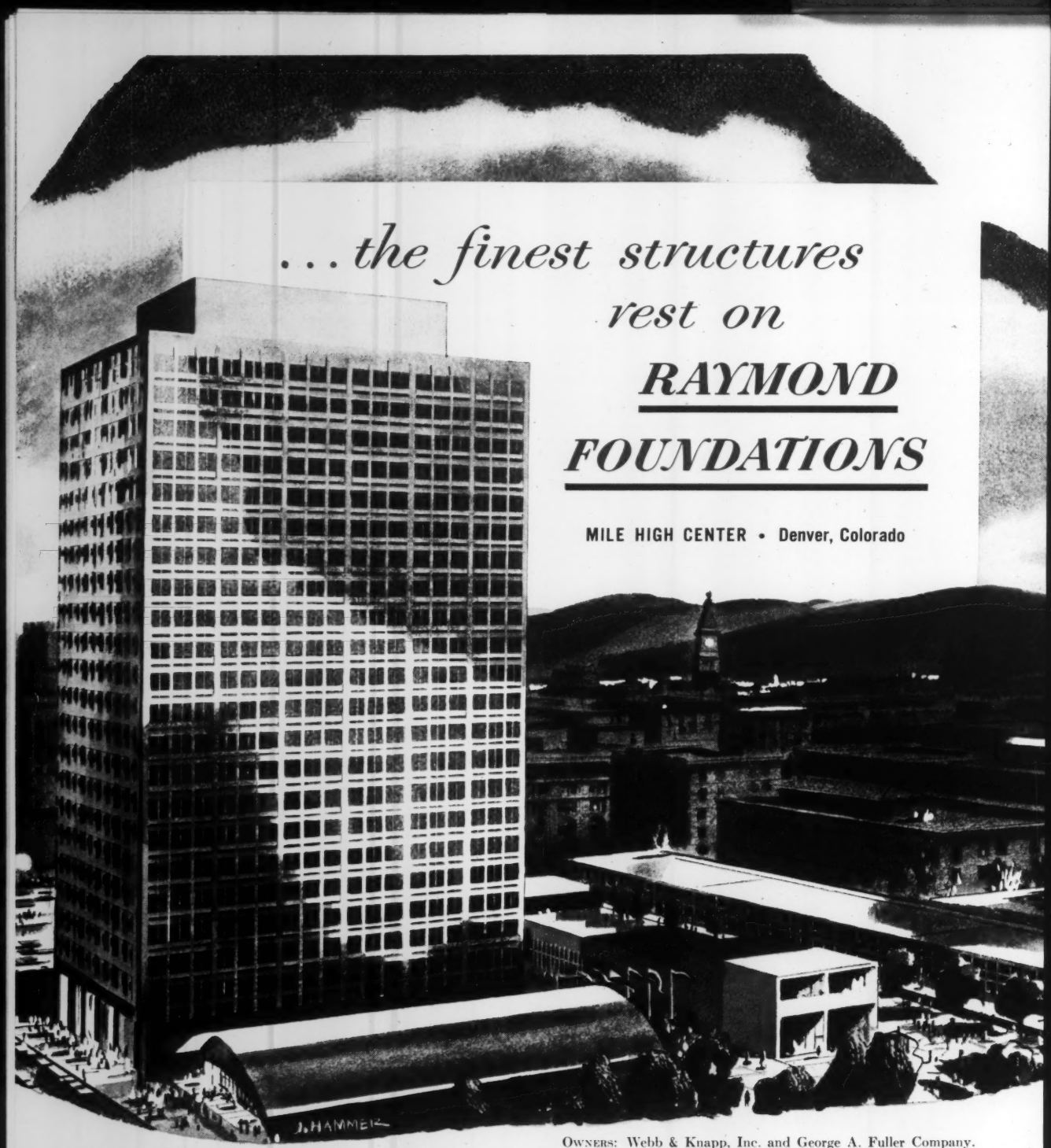
Two wings of building, showing panels and coping in place. It contains 1,400,000 sq. ft. of floor space and is the largest building of precast insulated panel construction in the world. ▼





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do you know that

The Mackinac Bridge is safe against all wind forces? Since the fall of the Tacoma Narrows Bridge in 1940, designers of suspension bridges have been aware of the need to guard against aerodynamic instability. In this issue Dr. D. B. Steinman, a pioneer in investigating the mathematical principles involved, describes how the $99,800,000 Mackinac Bridge, now under construction, was designed for complete aerodynamic stability. Another article discusses the precise surveys for the bridge, and a third tells how the foundations were constructed in rough water at record speed.

Advance purchase of highway rights-of-way can save millions of dollars? The California Department of Highways recently bought land for $19,000,000 which, it is reported, would have cost $114,000,000 if the purchase had been delayed until the project was ready for construction.

In the first three months of this year Engineering Societies Personnel Service had openings for 3,000 engineers? It filled 106 of these openings from a list of 600 applicants. If you are interested, the Service has offices in New York, Chicago, Detroit, and San Francisco (page 120).

Houston has built a domonstration monorail? The first hanging monorail passenger conveyance in the United States is having a try-out in Houston, Tex. The pilot project consists of a gasoline-powered glass and plastic car, which rides a 970-ft single elevated track. The car hangs from rubber-tired overhead wheels, has room for 60 passengers, and can go 60 mph. Costs are said to be less than for a subway or standard elevated system. Monorail, Inc., of Houston, built the test line.

Prefabricated aluminum houses are being used to help solve the housing shortage? The Colombian government has ordered 3,200 frameless Kingstrand houses (cost $3,000,000) for use in rural areas, where problems of terrain and transportation make home building difficult. Easily transported by plane, jeep, or burro, the lightweight aluminum houses come in 4 by 12-ft cartons along with nuts, bolts, and tools needed for assembly.

Highway transportation and allied activities account for about one-seventh of our gross national product? When the highway construction program now before Congress gets into full swing, annual expenditures are expected to reach about $8 billion. This estimate comes from an address delivered by A. C. Clark, Deputy Commissioner of Public Roads, at the recent annual meeting of the Western Association of State Highway Officials in Phoenix.

Pipelines constitute one of this country's major transportation systems? This year more than 17,000 miles of new gas and oil pipeline will be added to the existing 380,000-mile network. Some of the extremely difficult problems civil engineers must solve in laying the lines are the subject of a fascinating article by Stephen D. Bechtel, Jr., which is scheduled for the June issue.

Iron ore imports set a new record in 1955? Our ever-expanding iron and steel industry is doubling its efforts to have an adequate supply of iron ore and taconite pellets on hand, and the 26.3 million tons of imports in 1955 was by far the greatest tonnage ever brought into the United States in any year. Important new sources of supply include the Quebec-Labrador region; developments in Ontario; Cerro Bolivar and El Pao in Venezuela; new mines in Chile and Peru; and the Bomi Hills area of Liberia.

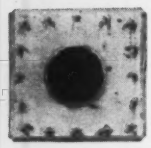
Canada is setting a rapid pace in developing its hydroelectric potential? In the past decade our neighbor to the north has added 7,000,000 hp of hydroelectric installation, and at the end of 1955 its total installed hydroelectric capacity had passed 17,500,000 hp. Even so only about 27 percent of available resources has been developed. Source of these estimates is Bulletin No. 2501 issued by the Canadian Department of Northern Affairs and National Resources, Ottawa.

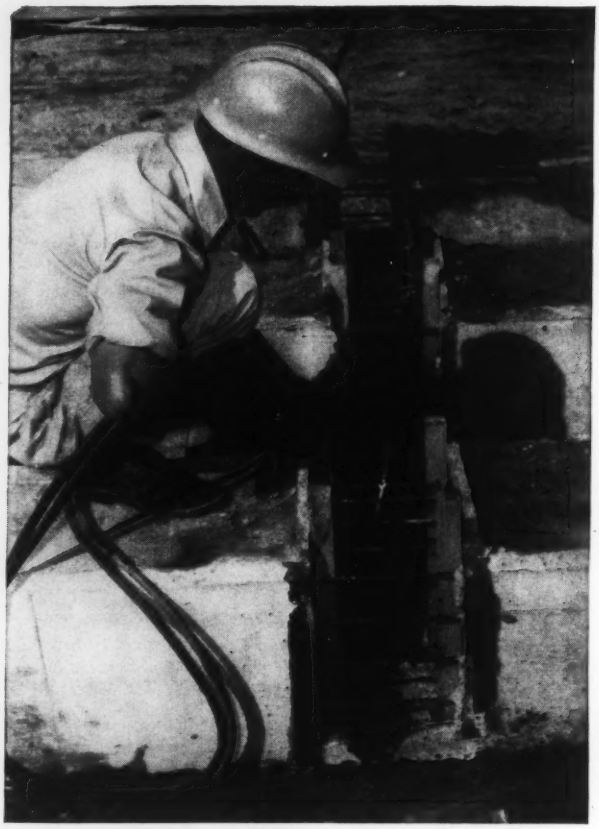
Solar energy promises great things for the future? The Association for Applied Solar Energy is initiating a quarterly newsletter, "The Sun at Work." The first edition of 10,000 copies will go to engineers and scientists in 37 countries. Headquarters of the Association, which recently sponsored a World Symposium on Applied Solar Energy, is the Heard Building, Phoenix.

You will miss a good meeting if you pass up the Society's Summer Convention in Knoxville, Tenn.? The Tennessee Valley Section is host to the Convention, June 4–8. TVA, an internationally famed center of engineering works, annually attracts professional men from all over the world. The exceptional technical and social program was printed in the April issue.

Prestressed Hollow-Core 'Incor' Piles

Speed Wharf Construction at Esso Standard Deep Water Oil Terminal





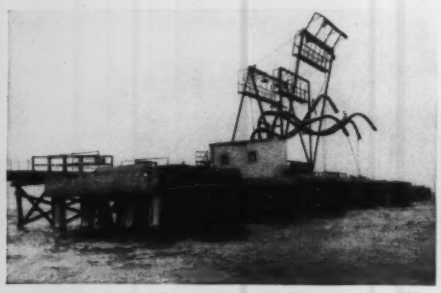
● Interesting feature of this wharf, recently completed at Esso Standard Oil Company's Deep Water Oil Terminal, Newport News, Va., is the use of precast prestressed hollow-core concrete piles in the tanker dock with its six reinforced concrete mooring and breasting dolphins.

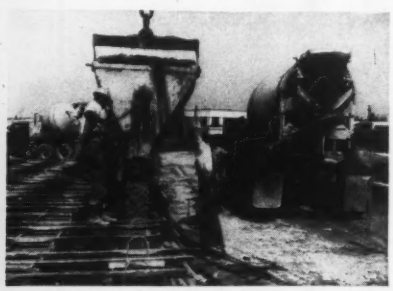
Piles average 77 ft. in length, with 18 x 18 in. cross section and 8 in. hollow core. A total of 151 prestressed piles were precast and pretensioned at job site, three piles at a time in each of seven 250 x 30 ft. pretensioning benches, using 'Incor'* 24-Hour Cement in the mix for faster re-use of the casting beds.

In the pretensioning bench, 'Incor' substantially reduces production time, and therefore cost, by providing dependable high early strength in 24-48 hours, making possible faster turnover.

In service, 'Incor' high-early and high-ultimate strengths assure quality concrete which is specially important in realizing the fullest advantage from prestressing.

*Reg. U. S. Pat. Off.





Above, left, new wharf is supported on 151 prestressed 'Incor' concrete piles, average length 77 ft. Piles were prestressed at job site: right, placing 'Incor' concrete in forms.

ESSO STANDARD OIL COMPANY—
DEEP WATER OIL TERMINAL
Newport News, Va.

Designed by
CARIBBEAN CONSTRUCTION CO., LTD.
Kingston, Jamaica, B.W.I

Engineers and General Contractor:
TIDEWATER CONSTRUCTION CORPORATION
Norfolk, Va.

Ready-mix 'Incor' Concrete:
BENSON-PHILLIPS COMPANY, INC.
Newport News, Va.

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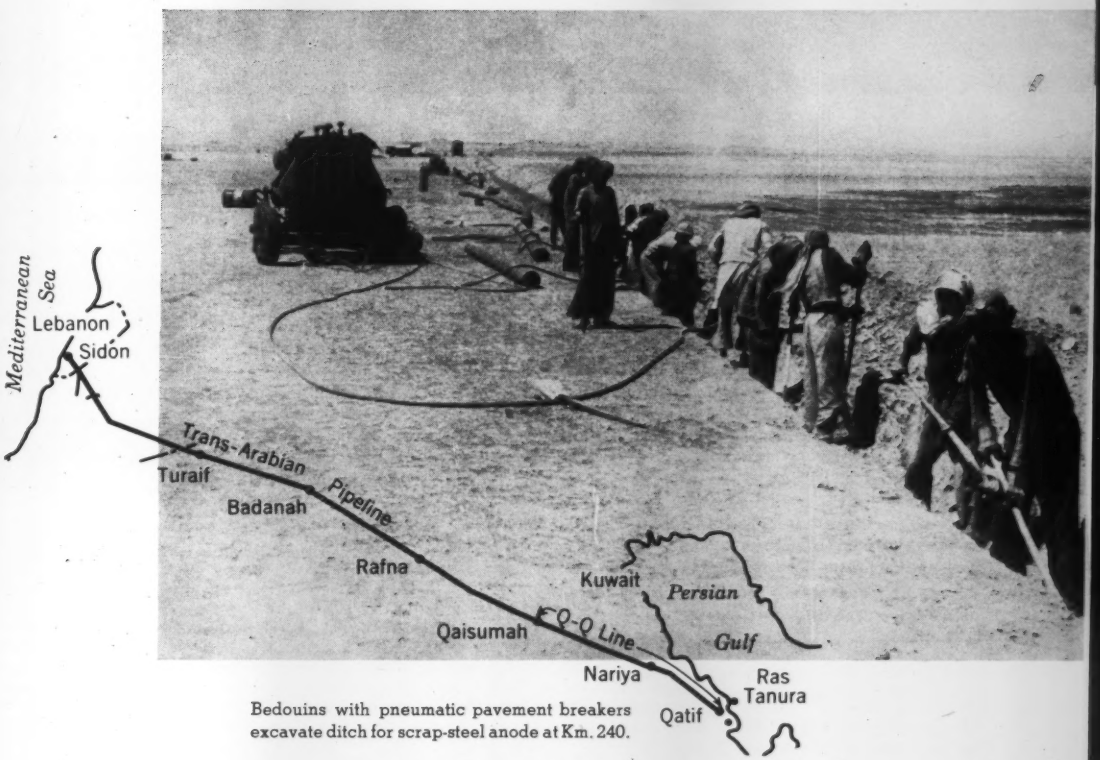


Bedouins with pneumatic pavement breakers excavate ditch for scrap-steel anode at Km. 240.

Cathodic protection for pipeline across Arabian Desert

KENNETH R. WRIGHT, J.M. ASCE

Construction Engineer, Arabian American Oil Company, Dhahran, Saudi Arabia

The necessity for an outlet on the Mediterranean for Arabian crude oil became evident immediately following World War II. It was realized that a pipeline would save a round trip of some three thousand miles for the many tankers hauling crude from the Persian Gulf to Europe. This pipeline, known as the Trans Arabian Pipeline, was completed in 1950.

The line was built from Qatif, near the producing fields, to Sidon, Lebanon. See outline map above. The oil producing company bore the cost of, and assumed

A Kenworth tractor and trailer rig heads out into the desert from Dhahran with supplies for construction forces. Water, equipment, and materials were transported in this way.

Fuel connection is installed from pipeline to feed diesel generator. Q-Q Line crosses soft wet areas on piling to avoid highly corrosive soil and difficult excavation. In distance it again goes underground.

responsibility for, the section between Qatif and the pumping station of Qaisumah. This section is 434 kilometers (269.5 miles) long and is known as the Q-Q Line (Fig. 1).

On the Q-Q Line the pipe has a wall thickness ranging from $^1/_4$ to $^7/_{16}$ in., the greater part being $^1/_4$ in. This pipe was manufactured of steel having a yield point of 52,000 psi. The protective coating for the buried part was applied at ditchside. It consisted of an asphaltic primer, a coat of asphalt, a single wrap of glass floss, another coat of asphalt, and finally a wrap of Perrault padding. This coating was chosen to give maximum protection from the high salinity of the soil. Even though the desert is extremely dry during most of the year, the winter rains are heavy, and large pools of water collect in depressions. These rains provide enough moisture in the ground throughout the year to introduce the problem of electrolytic action with its adverse effect on the steel-walled pipe wherever imperfections occur in the protective coating. To combat this corrosive action, cathodic protection for the pipeline was decided on.

This cathodic protection was installed concurrently with the construction of the pipeline. It consisted of a rectifier at Qatif, one at Qaisumah, and two at Nariya. When it was found that these rectifiers were unable to give proper protection to the line, welding generators were utilized on a temporary basis at intermediate points to supply electrical current to accompanying anode beds. In addition, a rectifier was installed at Wariah.

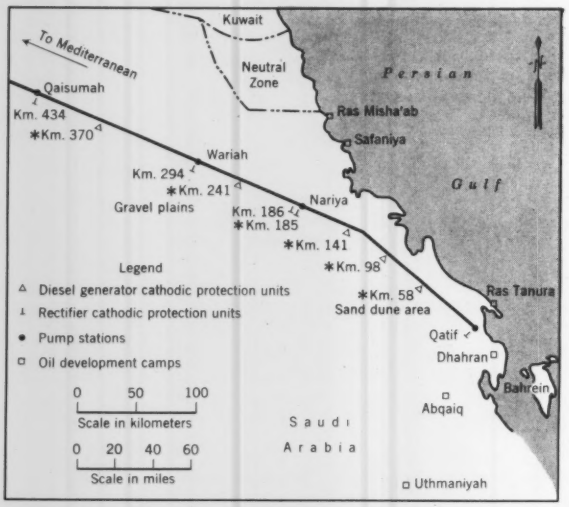


FIG. 1. Arabian crude oil is transported from Qatif to Qaisumah by Q-Q Pipeline. From there it is carried to the Mediterranean through the 30- and 31-in. Trans-Arabian Pipeline, as shown in map on preceding page. Detailed map, above, shows location of cathodic protection stations on Q-Q Line. Asterisks indicate stations included in work described in this article. Dhahran is oil company's headquarters, Abqaiq is in major producing area, and Ras Tanura houses refinery.

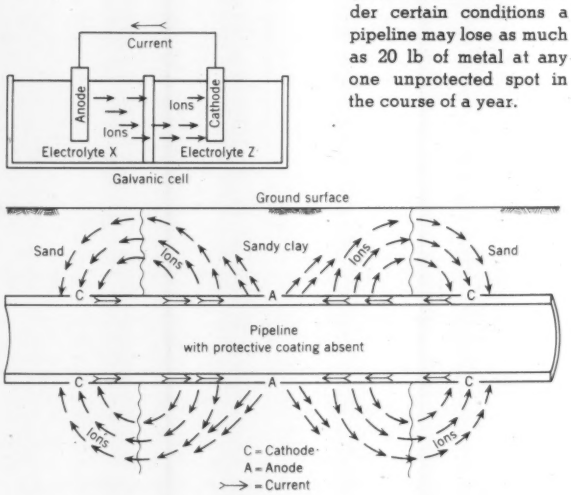


FIG. 2. Corrosive action on pipeline is similar to galvanic-cell action. Under certain conditions a pipeline may lose as much as 20 lb of metal at any one unprotected spot in the course of a year.

Arab welder joins sections of 8-in. pipe to form steel anode. This anode at Kilometer 240 had to be 500 ft long because of high soil resistivity.

Pipeline corrosion is very similar in its action to that of the galvanic cell battery with dissimilar electrolytes, as shown in Fig. 2. The point at which the electrons leave the pipeline is where rapid corrosion takes place. Here the current carries with it metal ions. These ions go into solution in the soil and are immediately exchanged for hydrogen ions. The metal ions then form a tubercle on the pipe surface similar to a scab. The hydrogen ions travel through the soil (electrolyte) to the cathodic part of the line, where a hydrogen film forms.

The method employed on the Q-Q Line to correct this situation was to make the soil-to-pipe electrical potential large enough to stop electron flow from the pipe to the earth. (See Fig. 3.) (The minimum satisfactory soil-to-pipe potential is 0.85 volts.) This was done by supplying an electrical current to the soil either through graphite or scrap-steel anodes. The current then traveled through the earth into the pipeline wherever a defect in the protective coating occurred. To complete the electrical circuit, the current traveled along the pipe to a lead running back to the generator or rectifier supplying the current.

Design problems

The problem of designing the permanent cathodic protection system for the Q-Q Line was a challenging one. The soil resistivity varies from as low a range as 30 to 100 ohm centimeters in the southern *subkha* (wet sandy clay) areas to a range of 10,000 to 200,000 ohm centimeters on the northern gravel plains. Adding to the difficulties is the fact that the pipeline crosses most of the subkhas on piling, much of it steel and not completely electrically insulated from the pipe.

The final design called for rectifier stations at Qatif, Nariya (here one of the rectifiers would have to be replaced to increase protection), Wariah and Qaisumah, plus diesel generator stations for the intermediate points. This made the average distance between stations about 40 km (24.8 miles) in the southern part and 65 km (40.4 miles) in the northern. This difference stemmed from the change in resistivity and the numerous steel piles in the southern subkha areas. The original rectifiers were producing power as follows: Qatif, 40 v and 100 amp; Nariya, 24 v and 190 amp; Wariah, 40 v and 100 amp; and Qaisumah, only a part utilized for the Q-Q Line, with most of the output going

Carbon anode has wire lead. These anodes were placed vertically in wet clay soil in groups of thirteen and surrounded with backfill of sodium graphite.

In sand dunes at Kilometer 58, which was inaccessible to tank trailer unit, a nomad excavates a well to supply water for concrete.

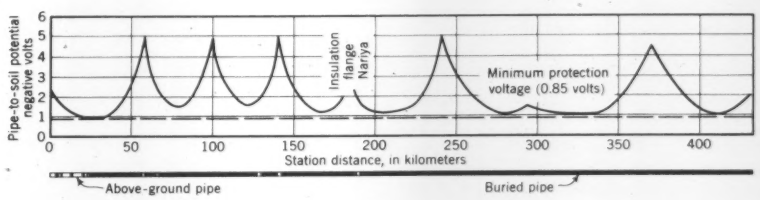


FIG. 3. Pipe-to-soil potential for cathodic protection of Qatif-Qaisumah Pipeline is shown by graph.

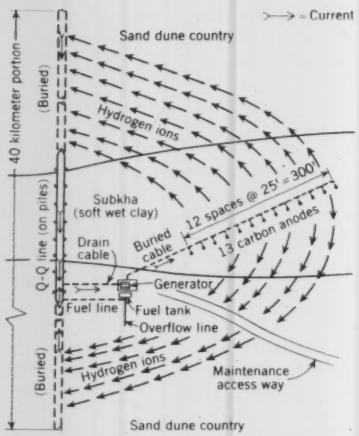


FIG. 4. Typical generator cathodic-protection station in sand-dune area includes anode bed. This was placed in soft wet clay because of its high water table (and consequent low resistivity) which resulted in more efficient distribution of hydrogen ions and higher ground-to-pipe potential.

into the Trans Arabian Pipeline. The specified direct-current output for the new rectifier at Nariya (Km. 185) was 60 v and 80 amp, and for each intermediate station, 60 v and 110 amps.

On the southern half of the line, in the subkha area and in the area of low-resistivity soil, the design called for carbon anodes (Fig. 4). These are more easily installed in soft wet clay soils than are scrap-steel anode beds, which require much excavation. The northern part of the pipeline would utilize scrap-steel anodes because of the large amount of contact area required between the anodes and the high-resistivity soil.

In designing the system, maintenance and fueling problems also had to be kept in mind, and these problems are magnified because of the remote locations of the generator units. The units must operate equally well during the blistering summer days and the near-freezing temperatures of winter. They must be able to withstand the sand storms that frequently blow over the desert. These problems were turned over to a vendor in one of the soft-currency countries—the Schweizerische Lokomotive and Maschinenfabrik of Switzerland. Specifications were for air-cooled generator units which could operate for a month without attendance—on crude oil taken from the pipeline. The units must operate at the full 6.6-kw continuous output at 125 deg F. Sunshades were needed to keep the hot sun off the shelter proper, and special filters had to be designed to remove all sand from the air before it entered the generator shelter.

Desert construction methods

According to the master project schedule, installation of the cathodic protection system was called for in the spring of 1955. Work was held up awaiting firm delivery dates of the diesel generators. In May it became apparent that the Swiss manufacturer was having difficulties in designing the units. Delivery could not be expected till the end of 1955. For economic construction it would have been wise to wait until the Swiss units were received before commencing the work; and yet, if the temporary anode beds then protecting the pipeline were not replaced promptly, costly repairs would be required on them. It was decided to begin Phase 1 immediately.

Phase 1 was to include all work except the installation of the Swiss generator units and shelters—portable welding machines to be utilized in their stead. These could supply satisfactory current for full-designed protection, the drawback being, of course, the expense of their operation in the desert.

The contract for the work was let to the lowest competent bidder—a Saudi Arab who had entered the contracting business several years previously after getting construction experience with the oil company. He belonged to a Bedouin family and understood his problems well. He was allowed two weeks to investigate the labor supply among the nomad tribes in the various areas, to hire native craftsmen to form the nuclei of his crews, and to set up material yards. Work was begun in June.

Construction equipment and water were furnished by the company and shipped out from Dhahran by Kenworth tractor-and-trailer rigs specially designed for desert travel. All material for one complete station was shipped at one time to keep transportation costs at a minimum. The company handled only the initial move to the Nariya area. The contractor elected to start in this area and work north so that his crews would be experienced by the time they tackled the work in the treacherous sand-dune region at Km. 58 and Km. 98.

Time and again situations arose that were peculiar to this part of the world, and were handled in a like manner. The engineer, anticipating difficulty in excavating for the required 5-ft-long carbon anodes, based the job cost estimate for excavation on a 1:1 slope in the subkhas. The contractor's method proved unique. As he dug down, he entwined camel grass in the clay, thus supporting the near-vertical sides long enough to place the anode and the special sodium graphite backfill.

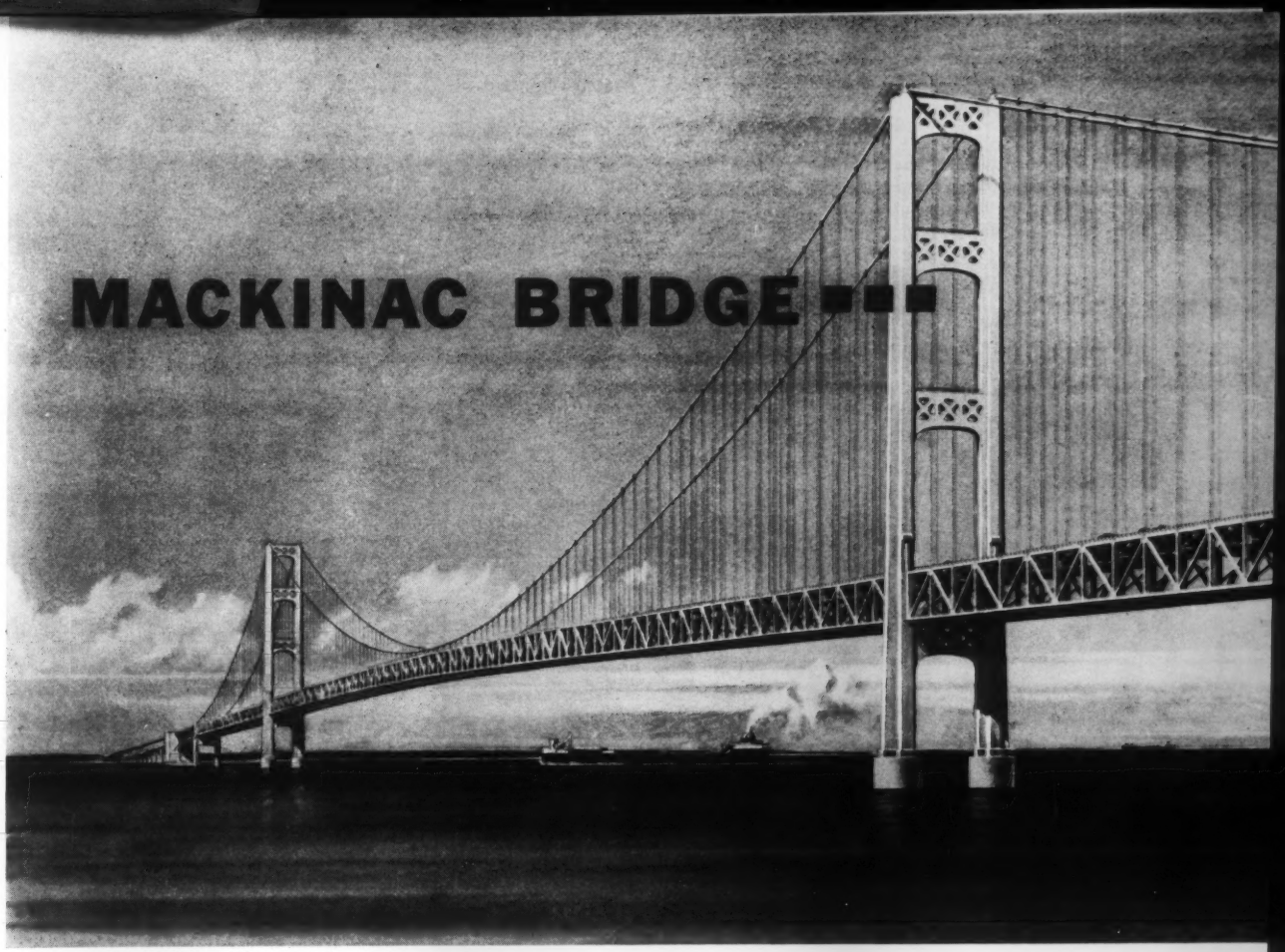
Between Nariya and Qaisumah, where the resistivity of the soil is very high, scrap-steel anodes were required. To improve the anode-to-soil contact, it was specified that 20 lb of salt per linear foot of anode be mixed into the backfilled earth. The salt was obtained by subcontracting its stockpiling to local tribesmen, who laboriously gathered the salt left in dried pools of water formed the previous winter. Aggregate for concrete was similarly accumulated.

In August, when the contractor finally came to the worst stretch—at Km. 58 and Km. 98—he had a well-seasoned crew and needed every bit of experience they had obtained. The rolling sand dunes made accessibility so difficult that neither water tanker nor construction equipment could be used. Concrete was mixed by hand in mortar boxes. The water for mixing had to be bucketed out of small open walls which the contractor dug near the waiting foundation forms. A 7-bag mix with a slump of 2 in. was utilized to offset the effect of the salty water. Welding here was done with oxygen and acetylene tanks rather than with the welding machine, and the fuel tank was set with the aid of cribbing, rollers, and hydraulic jacks. The aggregate had to be hauled all the way from the gravel plains near Nariya. Even the sand itself was a problem because of its wind-blown nature—it was so fine and rounded that it was useless for concrete. A typical generator cathodic-protection station is shown in Fig. 4. When this final section was finished in early September, the portable welding machines were connected to the electrical leads at each of the five sites as temporary power supplies.

Two months later the diesel generator units arrived in Saudi Arabia accompanied by a Swiss mechanic from the manufacturer. Now Phase 2 could be carried out. Each unit was inspected and given a test run while maintenance men received instructions in proper servicing techniques. The units were then transported out into the desert, set on the waiting concrete foundations, and tied into the fuel and electrical systems.

Since December 15, 1955, when the installation of all units was completed, the generators have been running on crude oil fuel with only monthly servicing. Together with the rectifiers, the units are supplying the full designed cathodic protection to the entire 434 km of pipeline from Qatif to Qaisumah.

During the course of the work here described, the writer was Construction Engineer for the Arabian American Oil Company, with headquarters in Dhahran, Saudi Arabia. He is now on leave of absence for a year doing graduate work in civil engineering at the University of Wisconsin.



Designed for complete aerodynamic stability

D. B. STEINMAN, M. ASCE, Consulting Engineer, New York, N. Y.

Design of the Mackinac Bridge is the culmination of 17 years of intensive pioneering investigation by Dr. Steinman of the scientific and mathematical principles involved in aerodynamic stability. This suspension bridge is a practical illustration of the principles that have been presented in his many published writings.

With the startling destruction of the Tacoma Narrows Bridge in 1940 by cumulative catastrophic oscillations in a mild gale, the engineering profession was awakened to the importance of considering the aerodynamic problem in bridge design. In striving to resist these potentially destructive forces, the more obvious, elementary methods ordinarily pursued tend to produce structures that are needlessly extravagant in cost and clumsy in proportions. In the case of the $99,800,000 Mackinac Bridge (under construction 1954–1957), a different course was adopted. A bridge of assured aerodynamic safety has been secured without sacrificing either economy or graceful proportions. By scientific design, utilizing the new knowledge of suspension bridge aerodynamics, this bridge, with its main span of 3,800 ft, has been made the most stable, aerodynamically, that has ever been designed.

The fundamental principles used in the design of this bridge are:

1. The phenomena of aerodynamic instability are not a mystery but can be reduced to predictive scientific analysis and prevention. A science of bridge aerodynamics is a reality.
2. It is more scientific (and much more economical) to eliminate the cause of aerodynamic instability by scientific design than to build up the structure, in weight and stiffness, to resist the effects of aerodynamic instability.
3. All bridge cross-sections do not behave alike, aerodynamically. They may be predictively differentiated and

Dynamic model used in wind tunnel tests at University of Washington was accurately built to scale of 1:50. It represents a 253-ft section of Mackinac Bridge.

classified as aerodynamically stable and unstable sections, of different degrees of stability or instability, in the three different kinds of potential oscillation—vertical, torsional, and coupled (combined vertical and torsional).

4. The aerodynamic characteristics of any proposed bridge section are either already known or may be predictively determined by simple model tests on a small-scale section model. Expensive, time-consuming wind-tunnel tests on a full-bridge model or on an elaborate large-scale oscillating section model are not required in predetermining the design. It is unscientific and unnecessary to spend years in groping experimentation with successive cut-and-try modifications of design.

5. The aerodynamic behavior of a bridge may be qualitatively and mathematically predicted from the simple lift and torque graphs previously recorded for different sections or obtained for a new section with a small-scale static section model in a small wind tunnel. The *slopes* of the graphs determine stability or instability. The *curvature* of the graphs determines limiting amplitudes.

6. The ideal bridge section, aerodynamically, is one that has zero slope of both the lift graph and the torque graph. Zero slopes in both graphs denote complete elimination of the lift forces and moments that produce aerodynamic oscillations.

7. Bridges of assured aerodynamic stability can be economically secured by simple modifications of the usual bridge sections. These modifications have been presented by the writer in successive publications since 1940.

Simple model tests

Based on fundamental conceptions of the aerodynamic forces and moments acting on a bridge section, simple modifications of the conventional bridge cross-section have been devised by the writer to eliminate the concentrations of differential pressure and the surfaces on which those pressure differences act. These modified sections can be easily and inexpensively tested and developed by means of simple, home-made office models, suspended from light springs and exposed to the breeze from an electric fan. The writer has operated this simple equipment in his lecture demonstrations since 1940.

The results of these elementary tests on inexpensive office models, confirmed and refined by tests made on a small-scale non-oscillating section model in a small wind tunnel, provided the basis for the design adopted for the Mackinac Bridge.

The confirmatory tests on the small-scale section model were made for the writer by Prof. F. J. Maher in the small wind tunnel at Virginia Polytechnic Institute. The model, only $8\frac{1}{2}$ in. wide and 15 in. long, was constructed by Prof. Maher to represent a 120-ft length of bridge to a scale of $\frac{1}{8}$ in. to the foot. The model was built to scale in accordance with the cross section shown in Fig. 1. Open-grid sections of the deck and open railings were simulated by wire screening. Graphs giving the variation of aerodynamic lift, drag, and moment with the angle of attack of the wind for this stationary model were plotted. These three graphs supplied the information to assure the aerodynamic stability of the bridge. The total cost of the model and the tests was $500.

Chief safety feature

The outstanding original feature giving the high aerodynamic stability of this bridge is the provision of wide open spaces between the stiffening trusses and the outer edges of the roadway. The trusses are spaced 68 ft apart and the roadway is only 48 ft wide, thus leaving open spaces 10 ft wide on each side, for the full length of the bridge. These wide lateral openings are located where the maximum aerodynamic pressure differences would otherwise be concentrated; such pressure differences ordinarily produce the critical alternating vertical forces inducing and amplifying vertical oscillations, together with the maximum lever-arms for these vertical forces in inducing and amplifying torsional oscillations. These lateral openings serve a dual purpose:

1. They equalize the aerodynamic pressures above and below the deck in these critical areas adjacent to the stiffening trusses or girders, thereby canceling the resultant alternating vertical forces.

2. They remove the area of solid deck on which these pressure differences would otherwise act. A pressure cannot exist and cannot produce a force without an area on which to act. (Force equals pressure times area; at one stroke we eliminate both factors in this product.)

The alternating pressure differences ordinarily concentrated in these corners of a bridge cross-section not only create the biggest alternating lift forces causing cumulative amplification of *vertical* oscillations, but they also operate with maximum leverage to produce the alternating torques causing cumulative amplification of *torsional* oscillations.

For further perfection, the equivalent of a wide longitudinal opening is provided in the middle of the roadway (Fig. 1). The two outer lanes, each 12 ft wide, are made solid, and the two inner lanes and the center mall (24 ft of width) are made of open-grid construction (of the safest, most improved type).

Simple model tests have shown that a design with open grid over the full width of the roadway does not produce aerodynamic stability. The solid deck, or a substantial part of it, is needed for atmospheric damping, to act against oscillations by atmospheric resistance. The Mackinac Bridge cross-section provides the solution. The two solid

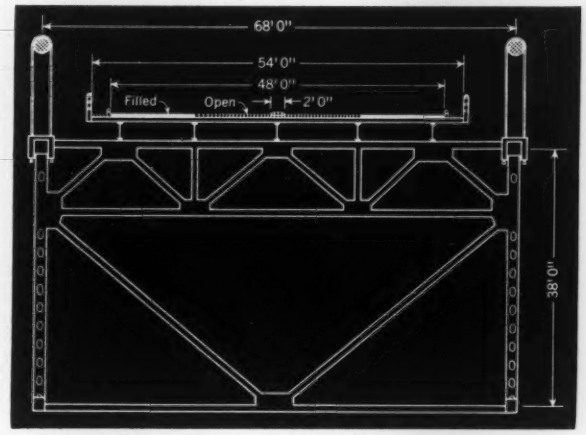


FIG. 1. Mackinac Bridge, seen in cross section, has ratio of truss depth to length of main span of 1:100. It is designed for highest degree of aerodynamic stability.

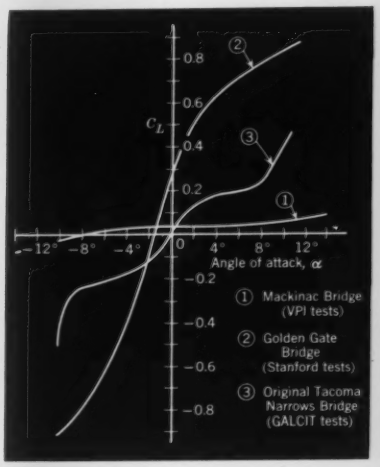


FIG. 2. Static lift graphs for three suspension bridges are compared. Ideal bridge section has zero slope of lift graph, which represents rate of increase of vertical lift with angle of attack. Different goal is sought in airplane wing sections, which call for maximum lift ratio.

roadway lanes, each 12 ft wide, supply the necessary atmospheric damping. Even in the two open lanes, a large measure of atmospheric damping is preserved by the friction of the air flow through the grid, with the velocity of this air flow augmented by the effect of the adjacent solid deck.

An additional design feature is the use of open-web, trussed floorbeams instead of the usual solid-web floorbeams. Aerodynamic oscillations of bridges have usually started under the action of quartering winds, blowing at angles of approximately 45 deg to the axis of the bridge. The longitudinal component parallel to the bridge axis, and acting on the transverse floorbeams and on the arched camber of the span, tends to start the oscillations; and the transverse component, acting across the span, then amplifies the initial oscillation if the cross-section has aerodynamic instability. The use of open floorbeams eliminates an important origin for the initiation of oscillations by gusts and quartering winds. The aerodynamically stable cross-section eliminates the amplification of oscillations, whether originated by gusts or by the imperceptible vibrations due to traffic. Any initial vibration or tremor is quickly damped, instead of being sustained and amplified.

Slope of static lift graph

The static lift graph is obtained simply by plotting the measured vertical lift force on a small section model held stationary at various angles of attack in a wind tunnel.

For comparison and contrast, the static lift graphs for three significant bridge sections are shown, superimposed and plotted to the same scale, in Fig. 2. The corresponding static torque graphs, for the same three bridges, are shown in Fig. 3. Taken from official records and published reports, the graphs for the Golden Gate Bridge were obtained in the wind tunnel at Stanford University; the graphs for the original (1940) Tacoma Narrows Bridge, in the Guggenheim Aeronautic Laboratory of the California Institute of Technology; and the graphs for the Mackinac Bridge, in the small wind tunnel at Virginia Polytechnic Institute.

The slope of the static lift graph represents the rate of increase of vertical lift with angle of attack. (A small correction, the "drag correction," is made in the plotted graphs in order to take into account the fact that the model is inclined, instead of the wind direction, to provide the various small angles of attack.) The slope of the static lift graph is significant.

A negative slope (lift decreasing with increasing angle of attack) would represent dangerous, catastrophic instability in vertical oscillations. A bridge section possessing this characteristic

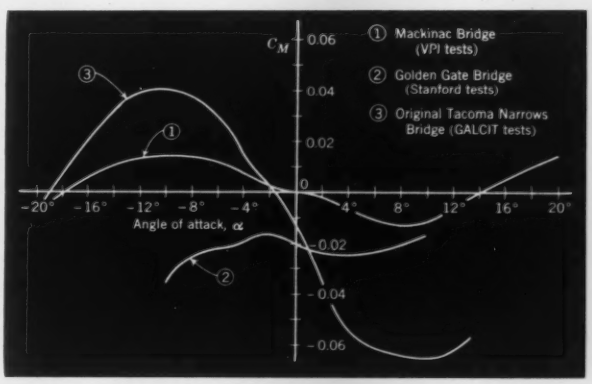


FIG. 3. Static torque graphs for three suspension bridges are compared. Zero slope for this graph, as for static lift graph, is ideal for bridge sections. Note steep negative slope for original Tacoma Narrows Bridge, indicating catastrophic instability.

would be subject to cumulative amplification of vertical oscillations to catastrophic amplitudes. Fortunately, only one suspension bridge in modern times has had this type of lift graph; the writer was retained to devise and recommend measures to make the bridge safe, and this was successfully and economically accomplished.

A positive slope of the static lift graph identifies vertically "stable" sections, so designated merely to distinguish them from "catastrophically unstable" sections. This distinction is clear-cut in the case of narrow geometric sections, such as lenticular sections, with the depth exceeding the width. In bridge cross-sections, however, a "stable" section, that is, one with positive slope of the lift graph, is subject to limited aerodynamic oscillations in certain critical ranges of wind velocity. These aerodynamic vertical oscillations usually occur at low wind velocities. Although they are not "catastrophic," these low-velocity oscillations are alarming, and they tend to shorten the life of the bridge by fatigue. This is the type of oscillation, commonly known as "galloping," which characterized the ill-fated Tacoma Narrows Bridge (1940) during the four months of its life.

TABLE I. Slope of static lift graph

Golden Gate	+10.5
Idealized airfoil	+ 6.28
George Washington	+ 6.2
Tacoma Narrows (original)	+ 5.5
Bronx-Whitestone	+ 5.0
Mackinac (grid covered)	+ 1.9
Mackinac (grid open)	+ 0.03
Ideal bridge section	0

TABLE II. Slope of static torque graphs

Tacoma (original)	−0.52
Bronx-Whitestone	−0.50
George Washington	−0.19
Golden Gate	−0.13
Mackinac (grid open)	−0.02
Mackinac (grid covered)	0
Ideal bridge section	0
Idealized airfoil	+1.57

TABLE III. Critical wind velocities for various bridges compared

Bridge	Critical Wind Velocity, miles per hr
Bronx-Whitestone, after addition of stiffening trusses	30
Golden Gate	40
George Washington	55
New Tacoma Narrows	76
Mackinac (with deck closed)	632
Mackinac (with deck open, as designed)	Infinite

In both cases, catastrophic instability (negative slope of lift graph) and limited instability (positive slope of the lift graph), the degree of instability in vertical oscillations is proportional to the slope of the lift graph. The steeper the slope, the greater the rate of amplification of the oscillations. The rate of increase is logarithmic, like a rate of compound interest applied cumulatively at each oscillation. The smallest tremor is automatically amplified a thousand fold to an amplitude of one or more feet in a few minutes.

Since the foregoing established relationship applies to all lift graphs, of either positive or negative slope, the conclusion is clear: The ideal bridge section for vertical stability is one that has zero slope of static lift graph.

In this respect, the goal sought in an ideal bridge section is quite different from that in wing sections for airplanes. "Flight stability" is something quite different from "aerodynamic stability." In the case of airfoil design, the objective sought is maximum lift, and the ideal airfoil is one that yields maximum ratio of vertical lift to horizontal drag. The idealized airfoil has a steep lift graph, with a slope of +6.28. The ideal bridge section has a flat lift graph with a slope of zero.

In Table I are listed the comparative slopes of the static lift graphs (corrected for drag) for some notable bridge sections. The idealized airfoil and the ideal bridge section are included for comparison. For completeness of presentation, Table I also includes the hypothetical case of the Mackinac Bridge with the grid in the middle of the roadway (24 ft of width) assumed completely covered, as by ice and snow. Even for this extreme assumed condition, the slope of the lift graph has the unprecedentedly low value of +1.9, or 5½ times as safe as the corresponding figure (+10.5) for the Golden Gate Bridge.

Slope of static torque graph

For the static torque graph, as for the static lift graph, the ideal slope is zero. Zero slope of torque graph means the elimination and complete absence of all forces and moments tending to induce and to amplify torsional (twisting) oscillations.

In addition to the steepness of the slope, the direction of the slope is of critical significance. A negative (downward) slope of torque graph identifies catastrophic torsional instability. This is the dangerous type of instability that destroyed the Tacoma Narrows Bridge.

A positive (upward) slope of torque graph identifies a so-called "stable" section in torsion, but such "stable" section is also subject to potential aerodynamic oscillations in torsion. In this case the aerodynamic oscillations are non-catastrophic; they are of limited amplitude (from a few inches to several feet) and occur at low wind velocities. Even such limited oscillations are troublesome and alarming, and weaken the structure by fatigue.

In Table II are listed the comparative slopes of the static torque graphs for some notable bridge sections. The idealized airfoil and the ideal bridge section are included for comparison. The idealized airfoil is the only one represented by a positive slope. For bridge sections, as has been stated, a zero slope (or a slight negative slope) is preferable. If the lift graph and the torque graph both have a positive slope, the bridge section is vulnerable to coupled oscillations, representing a dynamic combination of automatically synchronized vertical and torsional oscillations.

In the case of airfoils (airplane wings and tail surfaces), such coupled oscillations, known as "flutter," are a source of danger and have repeatedly proved disastrous. That is why zero slope of lift and torque graphs (or a slight positive slope of lift graph combined with a slight negative slope of torque graph) represents the ideal for bridge sections, eliminating all possibility of vertical, torsional, and coupled instability.

For the Mackinac section, the ratio is actually improved in the hypothetical case where the grid is completely covered by ice and snow, yielding an infinite ratio of superior torsional stability.

Combining the data of Tables I and II, as a measure of safety against coupled oscillations, the Mackinac Bridge section, as designed, is 6.5 to 350 times safer than the Golden Gate Bridge, and 26 to 183 times safer than the Tacoma Narrows Bridge.

Depth of stiffening truss

A suspension bridge that is aerodynamically unsafe can of course be made so by the simple device of providing excessive depth of stiffening girder or truss. By the writer's formula (specified for use "unless aerodynamic stability is otherwise assured") the required truss-depth for the 3,800-ft-span Mackinac Bridge (if it were unscientifically designed) would be 46 ft, or $1/_{82}$ of the span. But even this depth would be extravagant in cost and wasteful of steel.

For the Mackinac Bridge an ultra-conservative truss depth of 38 ft was actually adopted, yielding a convenient ratio of 1:100 of the span. In view of the assured, high aerodynamic stability of the design, a shallower truss-depth

would have been entirely safe. In fact, the Associate Consultant, Glenn B. Woodruff, M. ASCE, stated that, in view of the aerodynamically safe design, he would be satisfied with a truss depth of 12 ft.

In a suspension bridge, when correctly designed, the cost increases steeply with increasing depth of stiffening truss. By reducing the depth from 46 ft to 38 ft, several million dollars were saved. Because there are many who do not understand the fundamental principles of the aerodynamic problem, additional cost saving through a further reduction of truss depth had to be foregone. A barrage of uninformed criticism and attack had to be overcome. It was necessary to make certain sacrifices in order to retain the confidence of the public, the investors, and the insurance companies.

A double lateral system

As a further contribution to the assured safety of the aerodynamic design, a double system of lateral bracing was incorporated. By providing two planes of horizontal bracing, at or near the planes of the top and bottom chords of the stiffening trusses respectively, and extending over the full length of the suspension bridge, we secure the integral effect of a hollow rectangular section in torsion. The torsional stiffness of the structure is thereby greatly augmented, together with a corresponding high increase in the structural damping in torsion. However, in the light of the scientific design of the cross-section, the extra high torsional resistance secured by the double lateral system was really not necessary.

By the addition of the extra plane of lateral bracing, the torsional rigidity was increased seven-fold, from 115,000 ft-lb per ft to 832,000 ft-lb per ft, against one-segment oscillation (the main span assumed to deflect in a single segment); and nearly fourteen-fold, from 160,000 ft-lb per ft to 2,200,000 ft-lb per ft, against two-segment oscillation (the main span assumed to deflect in two segments, the mode that wrecked the Tacoma Narrows Bridge).

Tests confirm stability

Soon after the Mackinac Bridge bonds were sold and the contractors were notified to proceed with the construction of the bridge, arrangements were concluded by the writer, in March 1954, for a thorough aerodynamic investigation to be conducted by Prof. F. B. Farquharson, M. ASCE, in the Suspension Bridge Laboratory at the University of Washington. The purpose of these additional tests was to secure impartial, authoritative confirmation of the high degree of aerodynamic stability achieved in the design of the bridge. These investigations, costing $15,000, were completed and the results recorded in Professor Farquharson's Final Report, dated May 20, 1955.

The model used for these wind-tunnel tests was a 1/50-scale section-model, 60.75 in. long, with details of shape reliably duplicated, as shown in a photograph. The tests were made in a specially built open-jet wind tunnel with a wind jet 12 ft long and 4 ft high.

The extremely high aerodynamic stability of the Mackinac Bridge exceeded all prior experience in aerodynamic investigations. Professor Farquharson had to revise his test equipment when he found that this bridge had features of stability much higher than had ever been previously investigated. In fact, some of its features, such as the very high frequency ratio of 3.5 and the high estimated damping of 0.10 (for the iced condition) were too high to be fully duplicated in the model.

When the model was tested for the normal operating condition of the structure, namely, with the grids in the central portion of the roadway and the sidewalks open, absolutely no motion developed at any angle of attack up to the extreme value of plus or minus 20 deg (the limits of the wind tunnel) and over the full range of velocities available. These tests were conducted under very low damping conditions (0.005) which would reveal any slightest trace of instability; the actual structural damping in the bridge will be ten to twenty times as high (0.05 to 0.10), yielding further emphasis to this tested confirmation of complete aerodynamic stability. This is against vertical, torsional, and coupled oscillations.

Professor Farquharson also tested the model with all roadway and sidewalk grids closed to represent the hypothetical condition of such openings closed by ice. For this abnormal condition, the aerodynamic stability was found to be so nearly perfect that the difference was practically meaningless.

The bridge will also have an exceptionally high value of structural damping (resisting any tendency to start oscillations). The magnitude of this factor or logarithmic decrement will be at least 0.05. Professor Farquharson has estimated a structural damping factor of approximately 0.08. For the abnormal condition of all deck openings completely closed, the action of the interlocked ice and the packed snow will contribute further to the structural damping, and for this condition the structural damping may be estimated as 0.10.

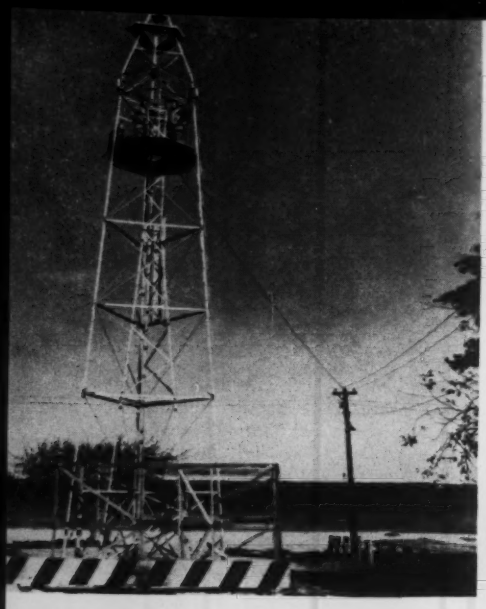
For a minimum assumed value of 0.05 for structural damping, the wind-tunnel tests for the bridge with the deck entirely closed (as by ice) show complete stability against vertical and torsional oscillations at all wind velocities; and against coupled oscillations at all wind velocities up to 524 miles per hour for the lowest mode of oscillations, 779 miles per hour for the next mode, and 800 miles per hour for the next higher mode. For the higher and more probable estimated value of 0.10 for the structural damping, the tests with the deck completely closed show complete stability against vertical and torsional oscillations at all wind velocities; and against coupled oscillations at all wind velocities up to 632 miles per hour for the lowest mode, 942 miles per hour for the next mode, and 966 miles per hour for the next higher mode. The indicated critical wind velocities for the assumed abnormal conditions approach the supersonic range and may be dismissed as fantastically impossible. The highest wind velocity ever recorded in the vicinity of Mackinac is 78 miles per hour.

A comparison of the aerodynamic stability of the Mackinac Bridge with that determined by similar wind-tunnel investigations for other notable suspension bridges is given in Table III, which lists critical wind velocities taken from published reports by Prof. F. B. Farquharson in official Bulletins (1954) of the University of Washington Engineering Experiment Station.

It is concluded that the Mackinac Bridge is one hundred percent safe, aerodynamically, even under the most adverse conditions that may be expected to occur. It represents the achievement of a new goal in suspension bridge design.

The bridge is being built for the Mackinac Bridge Authority—Prentiss M. Brown, Chairman; Mead L. Bricker, William J. Cochran, Charles M. Ziegler, Murray D. Van Wagoner, George A. Osborn, and Charles T. Fisher, Jr., members; with Lawrence A. Rubin, Secretary. D. B. Steinman, M. ASCE, consulting engineer, was retained by the Authority for design and supervision of construction. Glenn B. Woodruff, M. ASCE, consulting engineer, was retained by Dr. Steinman as consultant.

The design and office supervision of construction was divided among Dr. Steinman's associate engineers, as follows: Substructure and Main Towers, R. M. Boynton; Cable Work, W. E. Joyce, M. ASCE; remainder of Superstructure, C. H. Gronquist, M. ASCE; and Approach Viaducts and Roads, Toll Collection Facilities, and Administration Building, J. London. J. W. Kinney is Resident Engineer in charge of construction.



MACKINAC BRIDGE...

IT is one thing to locate a drawing of a structure accurately on a map and quite another to place precisely tons of steel and concrete across miles of open water. Such was the problem faced by the surveyors for the Mackinac Bridge. Baseline measurement presented no particular problem but establishing and maintaining triangulation stations in the stormy Straits was another story.

The Mackinac Bridge with its approaches is 26,195 ft in length and crosses approximately four miles of open water lying between the two Michigan peninsulas. This body of water, varying in depth from only a few feet to nearly three hundred feet, is characterized by strong currents and is subjected to severe weather conditions. Storms of substantial severity are not infrequent and arise quite suddenly. From December to March the Straits are frequently frozen to a considerable depth.

On January 19, 1954, D. B. Steinman, M. ASCE, consulting engineer, who designed and is now supervising the construction of the bridge, commissioned the G. Edwin Pidcock Co. to do all the surveying required to locate the substructure horizontally and vertically. On March 11, 1955, the firm was also commissioned to perform all the more common construction surveys required in the actual building of piers, abutments, and approaches. It is perhaps superfluous to state that in the location of the piers, first-order accuracy was required and guaranteed.

Between January 19 and March 6, 1954, all available information was collected from the consultant, the U. S. Coast and Geodetic Survey, the Michigan State Highway Department, and the U. S. Lake Survey. A reconnaissance survey was made at that time, and despite 22 in. of snow, several triangulation stations originally established between 1853 and 1896 were recovered. Additional Lake Survey triangulation stations were later recovered and tied into the major net. It should be noted that the success of the work to date is in no small measure due to the excellent cooperation received from the officers and men of the U. S. Coast and Geodetic Survey. Much information was received from the other agencies, although the Michigan State Highway Department was handicapped in its efforts to assist us because a lot of valuable data unfortunately had been lost in a fire. When the main survey party arrived on March 6, 1954, much of the area was covered by snow, the Straits were solidly frozen, and considerable difficulty was encountered in the recovery of triangulation stations and bench marks.

Although the number of men and type of organization varied throughout the course of the work, the survey force generally consisted of a resident engineer, four observers, two recorders, two light keepers, a computer, one party chief, one instrument man, and two rodmen. It is interesting to note that an unusual personnel problem arose as a result of the heights at which many of the men were forced to work. Repeatedly it was found that men who had nearly every other qualification were ineligible because of the height factor.

Triangulation net consisted of eight land stations supplemented by a minor net of six sea stations. Bilby tower (top) was used on seven of the eight land stations. Sea towers (middle) were specially designed for project. Note that tower is a single unit and not conventional tower-within-tower design. In photo at bottom a cofferdam frame is being positioned by means of four sight bars fixed to frame in predetermined positions. These bars were aligned with survey towers at site. Note sighting bar just to right of workman in foreground.

Special equipment

Much of the equipment used is considered standard on projects of this character. It included Wild T-2 and T-3 theodolites, U. S. Coast and Geodetic Survey precise levels, Wild N-2 levels, specially calibrated (U.S. Bureau of Standards) Lovar and Invar tapes, collimators, signal lamps, O-tents, ground tents, Bilby towers, and Lovar and Invar level rods. In addition, however, special equipment was required and it was in the procurement of this that many of the problems arose.

G. EDWIN PIDCOCK, M. ASCE

Directing Head, G. Edwin Pidcock Co., Allentown, Pa.

Located with first-order precision

Because of the nature of the work, and especially during the setting of the cofferdam frames, it was essential that immediate and continuous communication be available between the office and all field personnel. The distances involved precluded the use of any communication other than that provided by portable radios; consequently four field radios and one base station were placed in operation, but only after considerable difficulty.

Orders for radios were placed with one manufacturer in February 1954, but it was found impossible to obtain prompt delivery. The purchase of war surplus "walkie talkies" was then attempted, but proved impractical because of the necessity of changing the operating frequencies to conform to FCC civilian requirements. A second manufacturer was next contacted and delivery of three sets secured. Maintenance troubles then became paramount, and the final, completely satisfactory arrangements were made with the Michigan Bell Telephone Co.

A similar problem was encountered in securing a "straddle target," a special target actually consisting of two light boxes accurately mounted on a rigid calibrated base. (The use of the target is described later.) The original straddle target was designed and built by the U.S.C. & G.S., and there are no similar devices on the market. Consequently a new design patterned after the original was made, and a special tool maker was employed to produce it. After some delay and experimentation a satisfactory model was perfected and placed in operation.

Transportation was provided on land by an average of two station wagons and one truck, and on the Straits by a 37-ft boat powered by a 160-hp diesel engine.

After a study of the available data, it was decided to establish a major land triangulation net using three previously established stations and five new stations (see Fig. 1). It had originally been intended to use a base line on the southern peninsula which had been established in the nineteenth century, but this was made subordinate to a new 10,858.443-ft base line on the northern peninsula along highway U.S. 2. Accordingly, on March 23, 1954, the first of the eight towers (7 Bilby and 1 latticed) was erected, and at the completion of all eight towers the major triangulation was begun.

As a supplement to the major net and to facilitate location of the 34 piers, a minor net of six sea towers was subsequently established. Three towers were placed on each of the 2,000-ft offset lines—three east and three west of the bridge centerline. The longitudinal locations were carefully chosen to produce the best angles for cutting in each of the piers, within the limits imposed by the depth of the water, which varied from 26 to 93 ft. The design of the water towers was made jointly by Merritt-Chapman & Scott Corp., D. B. Steinman, and our firm. Although it was not the customary tower-within-a-tower design, no serious vibration problems were encountered.

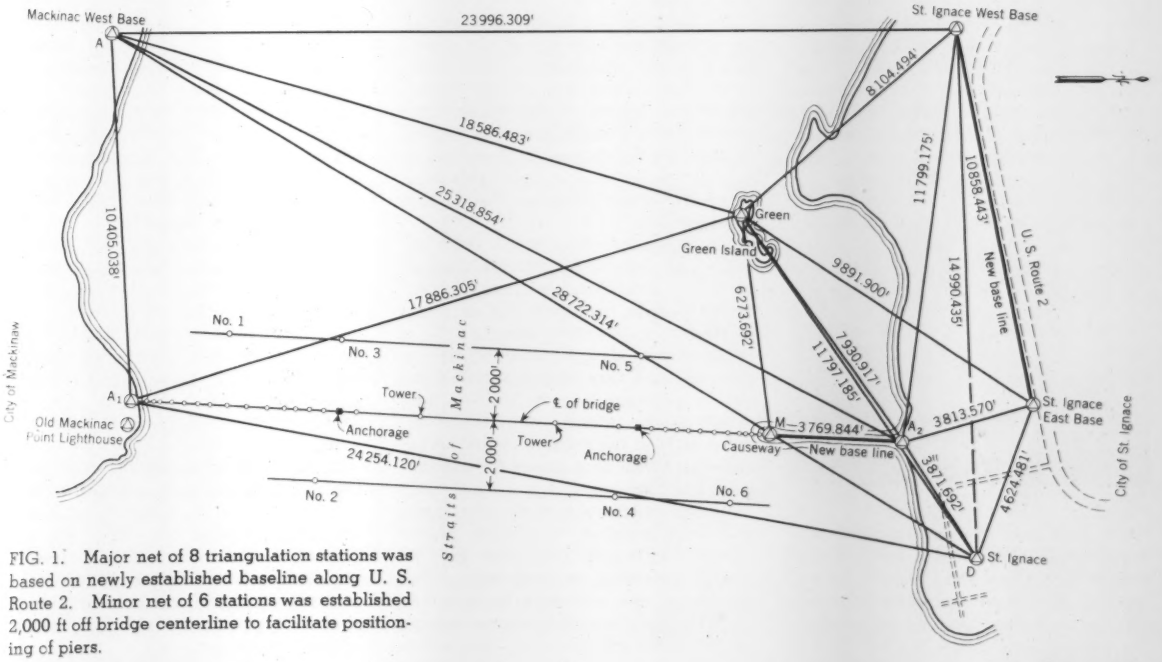


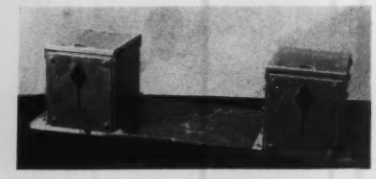
FIG. 1. Major net of 8 triangulation stations was based on newly established baseline along U. S. Route 2. Minor net of 6 stations was established 2,000 ft off bridge centerline to facilitate positioning of piers.

At a later date some consideration was given to the provision of a separate landing stage, on account of the difficulty experienced in transferring heavily laden men from a tossing boat without damaging the towers. However, the urgency of the work prevented the accomplishment of this modification. It may be of interest to note that the entire sea-tower net had to be reestablished in 1955; this was because the towers had to be removed during the winter to avoid their loss through ice action. Actually, one of the more protected towers was allowed to remain in the Straits as an experiment but, as feared, it was damaged by the ice early in the winter.

Base line measured

The accurate measurement of the base line along U.S. 2 was accomplished in the following manner. Chaining bucks with copper scribe plates were first set, and the base line was then measured in sections with three separate 100-meter Lovar tapes. The line was then measured again using a different tape for each section. Since the two runs checked within first-order limits, no further measurements were required. Temperature and tension readings were made with the measurement of each length. Simultaneously a leveling group ran levels over all the bucks in order to compute the inclination corrections. Computers then analyzed the results and figured the necessary corrections.

Much of the triangulation work was performed at night to permit the use of lights and to eliminate excessive refraction. The average error of closure for the triangulation of the major net done in 1954 was 1.04 sec. The closure between the original points (A. Mackinac West Base, D. St. Ignace) and the new St. Ignace Base was 1 part in 628,000. The lengths were determined with an error of less than 1 part in 100,000. The average closure of the triangulation of the water towers in 1955 was 1.11 sec. and the lengths were determined with accuracies similar to those obtained the previous year.



"Straddle target" consists of two light boxes accurately mounted on rigid calibrated base. Original was designed and built by U. S. Coast and Geodetic Survey. Use of this target increased accuracy and reduced time required to establish centerline points on piers.

Apart from the normal difficulties experienced by a triangulation party, nature contributed an additional and unexpected annoyance—sea gulls. Observers were literally dive-bombed; signal lights were inexplicably obscured—by gulls perched in front of them; and the towers were rendered almost unoccupiable. The gulls were particularly disturbed by any intrusion on Green Island, which is apparently their breeding place in that area.

Setting cofferdam frames

Setting of the cofferdam frames was successfully accomplished by a method devised to meet the project conditions. The frames were fabricated at a dock on the northern peninsula, and when completed were loaded on barges and floated out to their assigned positions. Before leaving the dock, each frame was accurately measured and four points selected for future use in the field location. The coordinates and azimuths of these points from the sea towers to be used, were computed for the frame in its final position. When the frame reached the pier location, sight poles were placed on the previously determined points and checked. The frame was then maneuvered into position until the two sight poles used by one observer were perfectly aligned. When the poles were aligned in each of the observed directions, spur piles were dropped through special brackets and driven into the lake bottom.

During these operations, and during the setting and driving of the sheetpiling, it was necessary to check continually the alignment of the frame. When the setting of the frame continued into the night, a special system of pulsating lights was employed so as to distinguish the sight-pole lights from the many other lights on the marine equipment.

When construction work was occasionally delayed by adverse weather or other conditions, it became necessary to man the towers for as many as thirty consecutive hours. As a result of the dangers inherent in remaining on a tiny platform placed far out in an open lake for such a long period in the intense cold, it was decided early in the work to avoid leaving one man alone on a tower for any appreciable time.

As the construction work progressed, it became necessary to furnish an accurate longitudinal centerline and accurate stationing for each pier. The stationing was provided by observations from the appropriate water towers or by direct measurement, but a different method was used in determining the centerline.

Barring the occurrence of temporary obstructions such as derricks, and until the piers reached an advanced stage of construction, it was possible to sight directly from Station A-1 to Station A-2, two points previously placed on the longitudinal bridge centerline. Centerline points had also been established by triangulation on Piers 17 and 22.

To increase accuracy and reduce refractive and other errors as well as to save time in establishing similar points on the remaining 32 piers, the straddle-target method was used. With the transit set on the bridge centerline, sets of angles are turned from one light box on the straddle target (placed to straddle the centerline) to a backsight target on the centerline, thence from the backsight target to the second light box. As a check, this procedure is repeated with the straddle target in a second position astride the centerline. In each case, the centerline of the straddle target was scribed on the pier before the target was removed. Finally, the true position of the centerline was calculated from the observed angles, the spacing of the light boxes and the known distance from observer to straddle target. The centerline was then established by direct measurement from the scribe marks.

Vertical control accurately completed

In establishing the vertical control elevations for each pier, the "river crossing" method, which is a reciprocal precise leveling method, was repeatedly employed. After considerable effort, which included the detection of unusual play in the micrometer screw of one of the geodetic levels, the four miles of water were crossed in a number of steps, and the levels were closed within 0.004 ft. This crossing was the first time that the northern and southern peninsulas had been linked by a direct run of precise levels.

Perhaps the climax of the entire two years of surveying work came during the placing of the first truss span—the 468-ft backstay truss. The truss was mounted on barges which after being floated into position were gradually filled with water. As the truss settled on the piers, the "fit" was determined to be within less than one-half inch.

It was with considerable relief and much satisfaction that our parties left the project in its present advanced stage on December 16, 1955. We are pleased to have been associated with the designers of such a monumental structure, and to have been permitted to make even a small contribution to the total effort.

MACKINAC BRIDGE . . .

Foundations constructed at record speed by unusual methods

R. M. BOYNTON, Associate Engineer, with D. B. Steinman, Consulting Engineer, New York, N. Y.

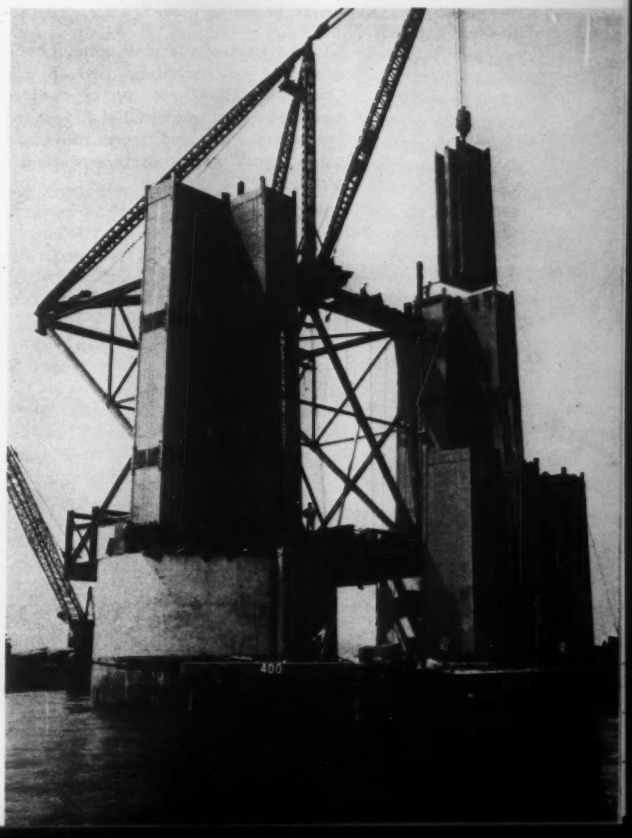
In the construction of the Mackinac Bridge, necessity once more played its maternal role. Adverse climate, the shortness of the construction season, and the magnitude of the structure led designers and builders to modify generally accepted methods. In construction even more latitude was required to assure virtual completion of the substructure in two short construction seasons. To reduce foundation loads, pier bases were topped off 8 ft below the surface, and piers were made circular and single-shafted where possible. Concrete placing by the Intrusion Prepakt method meant that the coarse aggregate was placed directly in the forms, thus reducing the load on the mixing plant and greatly speeding up the pouring program.

The size of the bridge is indicated by the volume of concrete in the foundations, 440,000 cu yd; by the cost of the foundations, $25,735,000; by the depth to foundation rock, a maximum of 206 ft below the water surface; and by the economic necessity of sticking to a tight schedule even when hampered by rain, snow, ice, wind, and rough water on the open Straits.

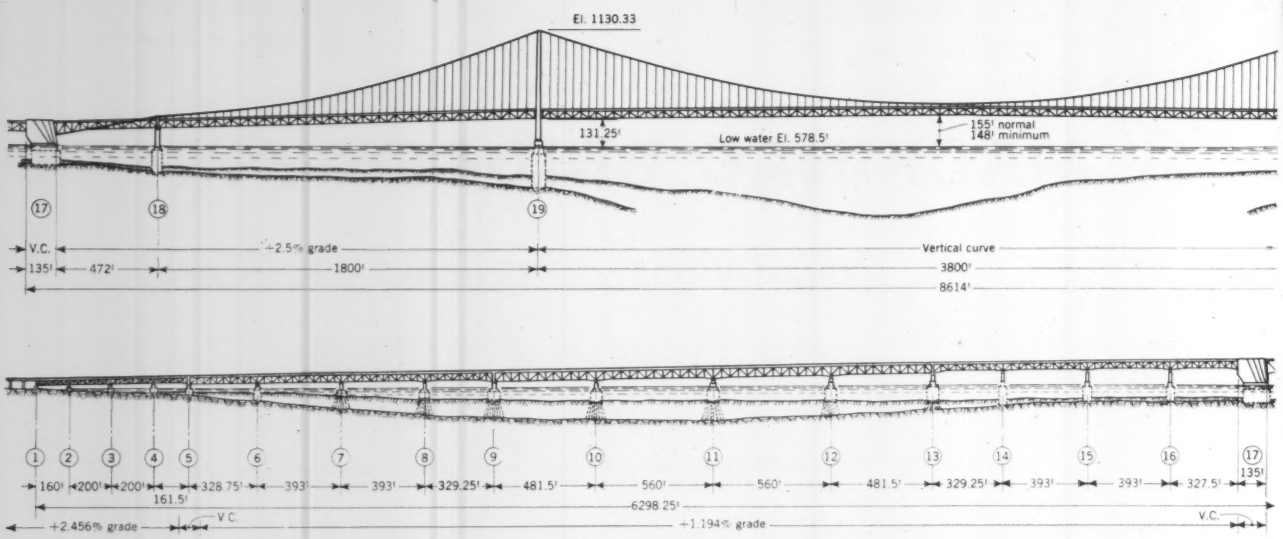
Near the center of the suspension span, the depth of water reaches a maximum of 252 ft. The maximum water depth involved in pier construction was 140 ft at the south main tower pier, and the depth to rock for the main piers varied from 80 ft below the water surface at the south anchorage to 206 ft at the south main tower pier. There is a secondary gorge approximately midway between the south shore and the south anchorage of the suspension bridge. Here, at Pier 11, the rock dips to a depth of 185 ft below the water surface.

Unusual geologic formation

The geology of the area and the capacity of the unusual breccia formation to sustain massive bridge piers have been the subject of extensive studies by geologists and engineers for many years. Formation of the Mackinac breccia began some 300 or 400 million years ago, in early to mid-Devonian times, when an uplift of the land mass took place in the area of the Straits, allowing ground-water movement and therefore leaching of the salt beds of the Salina formation of the Silurian period. As a result of this leaching action, two important geological formations came into being, the Detroit River and the Mackinac Straits. As the brine-laden water worked its way into the Michigan Basin, the salt beds of the Detroit River formation were established, while



Tower bases were fabricated in four approximately equal sections, having maximum weight of 48 tons. Three bottom sections shown in place were erected by floating crane, which then erected creeper traveler here shown erecting next section of tower.

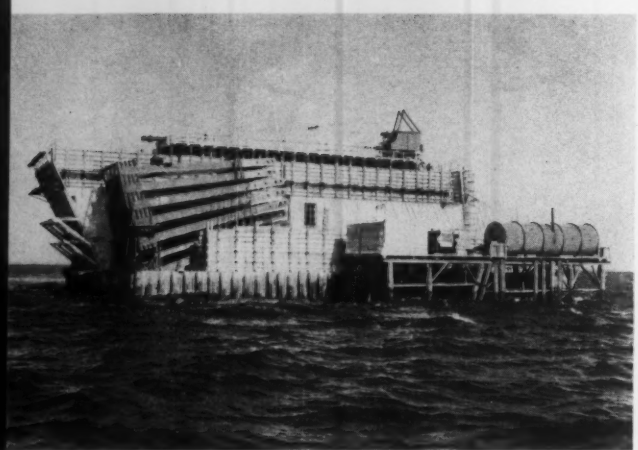


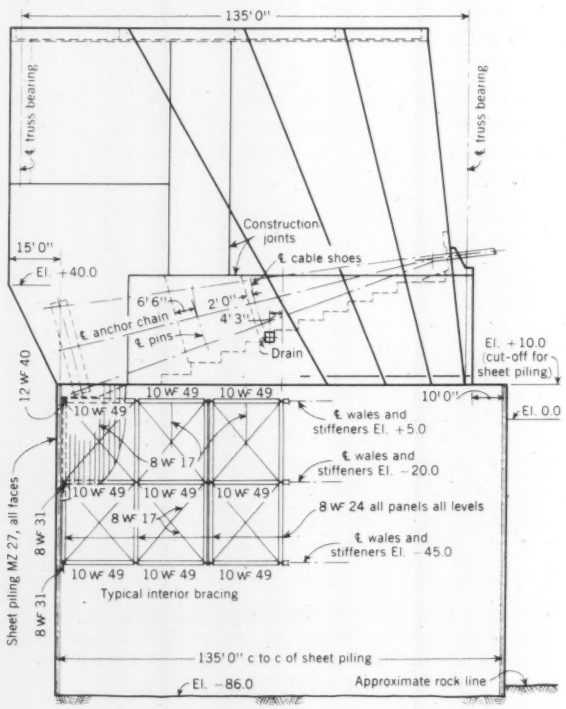
South truss spans

the solution of large quantities of rock salt simultaneously created great voids or cavernous areas with a rock roof consisting of shales, limestones, dolomites, sand shales, and gypsum or anhydrite. These roof deposits were represented by the Salina (Pointe aux Chenes) and Bass Island (St. Ignace) formations of the Silurian age and the Garden Island, Bois Blanc, and Detroit River formations of the Devonian period. The caverns finally reached such proportions that the overlying rock collapsed. Although the period of collapse was probably long and the rate variable, the end result was an area of broken mixed angular rock which was later recemented to form the so-called Mackinac breccia. The size of the components making up the breccia is believed to vary from small fragments to huge blocks.

Borings and probings were made at the site in 1939. Compression tests on samples of the material and in-place loading tests made in 1950 indicated a yield value of approximately 60 tons per sq ft. Additional borings, varying in number from one to four at each pier site, were made in 1954-1955 as the work progressed. These borings show the presence of cherty dolomitic limestone, dolomitic limestone, calcareous dolomite, dolomite, calcite, limestone, clay carbonate, and red and green shales. Dolomitic limestone predominated at

FIG. 2. Largest and most difficult cofferdam was for anchorage pier, No. 22. Containing 85,000 cu yd of concrete, anchorage must resist pull of 30 tons from two cables. In photo, fourth lift is being poured with cable anchorage steel in place.





Side elevation

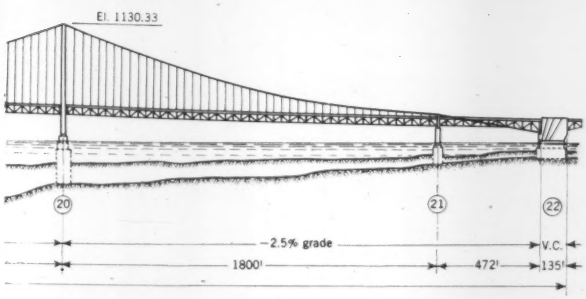
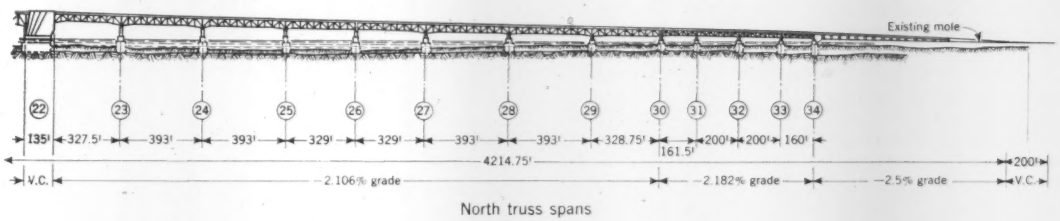


FIG. 1. Of the 33 water piers, 30 were built in open cofferdams and 3 (Nos. 18, 19, and 20) in open-dredged caissons. Piles were used for Piers 7 to 13 inclusive, at the secondary gorge, where rock was very deep and covered with deep, relatively stiff overburden.



North truss spans

most locations. These borings confirmed the results of previous borings and tests. No measurable settlement has taken place at any pier to date.

Foundations were designed for the usual vertical dead and live loads plus buoyancy, with an allowable rock pressure of 15 tons per sq ft. This working stress for the rock yields a factor of safety of four based on the results of the above mentioned load tests. The foundations were also designed for a wind pressure of 50 lb per sq ft on the superstructure; an assumed ice pressure of 115,000 lb per lin ft on the rectangular piers, and 65,000 lb per lin ft of diameter on the circular piers. For toe or edge pressures caused by the overturning moment from wind and ice, a value of 25 tons per sq ft was allowed. The assistance of passive earth pressure from the overburden in resisting horizontal forces was neglected, thus augmenting the generous factor of safety in the foundation design.

For Piers 7 to 13 inclusive, at the secondary gorge, where rock was very deep and covered with a deep layer of relatively stiff overburden, economy was obtained by using 14-in. 117-lb steel H-piles driven to, and seated in, rock. See Fig. 1. The concrete foundation was carried a minimum of 10 ft into the overburden to absorb shock from any sudden horizontal forces, and the piles were embedded in the concrete a minimum distance of 10 ft to assure a fixed-end condition. Piles were designed for 9,000 psi for dead and live loads with a 25 percent allowable increase for dead, wind, and ice loads. Pile tips were reinforced with plates and angles of sufficient section to reduce bearing on rock to 6,000 psi and to guard against damage by heavy driving.

Accurate measurements of thickness of solid blue ice in the Straits were made throughout the winter of 1954–1955, reported to be about an average winter for the locality. The maximum thickness recorded was 18 in., but this thickness is undoubtedly exceeded in certain years. Local residents report massive floes at times, particularly when ice from Lake Michigan or Lake Huron is driven into the Straits by winds from the west or east respectively.

To minimize the effect of ice loads on piers, three design features were adopted. First, the massive bases for all piers, except the two anchorages, were discontinued at El. − 8 instead of carrying them up above water to El. + 10 or more as is usually done. Second, the pier shafts above El. − 8 were made circular and heavily reinforced to permit minimum diameter, thus presenting minimum obstruction to ice flow. Third, circular, single-shaft hammerhead piers were used where pier height made this type feasible, thus eliminating the ice forces which might otherwise develop from arching or jamming between the twin shafts of the more conventional type of pier.

Pier bases made solid

Comparative cost estimates indicated that there might be a very slight economy in the use of a hollow or honeycomb type of base for the largest and deepest piers. It was difficult to justify the additional cost of forms for this type of construction when for practically the same amount, enough concrete to form a solid pier could be furnished. Therefore solid piers were selected for strength, durability, resistance to shock from ice floes or derelicts, and simplified and speedy construction.

Use of solid piers, with their greater dead weight, was also advantageous in securing a favorable factor of safety against overturning moments caused by the very large wind and ice loads. The resultant of all forces was kept within the one-sixth point for bases of rectangular piers, and within $0.59R$ of the center for bases of circular piers. The resulting factor of safety against overturning would be substantially increased by the passive pressure of the overburden, which was neglected.

The use of embedded structural steel trusses in lieu of bar reinforcement in portal struts and hammerheads, as employed on the Garden State Parkway Bridge over the Raritan River and the Kingston-Rhinecliff Bridge, was particularly adaptable to the Mackinac Bridge. Such trusses were designed to support the forms, carry the dead weight of the green concrete, and then serve as concrete reinforcement. Some bar reinforcement, such as surface reinforcement to prevent shrinkage cracks, bars to produce additional section at strategic points, etc., was used and completely assembled with the trusses. Such prefabricated units, set in a few hours, were a major factor in speeding the construction of piers in the Mackinac Straits, where rough water often delayed more time-consuming operations.

Prepakt concrete simplifies placement

One of the most critical and time-consuming items of work was the placing of concrete. This is spotlighted by the following concrete volumes: 75,000 cu yd in each of the main tower piers, Nos. 19 and 20; 85,000 cu yd in each of the two anchorage piers, Nos. 17 and 22 (Fig. 2), and a total of 440,000

cu yd in the 33 water piers. All this had to be placed in two short construction seasons from floating equipment in the Straits, which are frequently subject to wind storms and very rough water. To place such yardage, mostly in huge tremie pours, would have been a herculean task subject to the danger of discontinuous pours resulting from normal hazards augmented by the additional hazard of severe wind storms. Therefore Intrusion Prepakt concrete was used in all the piers to facilitate construction and to eliminate the hazards inherent in huge conventional tremie pours.

With the Prepakt method, the coarse aggregate is placed directly in the forms, cofferdam, or caisson, and the Intrusion mortar is pumped in through previously placed pipes to fill the voids. The coarse aggregate, with about 40 percent voids, represents about 60 percent of the total volume of the concrete. With this method, 60 percent, or 264,000 cu yd of stone, was placed directly in the forms without passing through a concrete mixer. The load on the mixing plant was thus reduced to 176,000 cu yd of mortar, composed of cement, fly ash, Intrusion Aid, water, and sand.

Coarse aggregate was graded in size between $^1/_2$ in. and 6 in. The minimum size was specified to insure about 40 percent voids to permit free flow of mortar. The maximum size was determined only by that economically available, convenient to handle, and suited to the spacing of reinforcement. Cold joints in Prepakt concrete, caused by interrupted grouting operations, are usually barely perceptible to the naked eye, and the use of 6-in. stone provides an excellent key at such joints.

Of the 33 water piers, three were built in open-dredged caissons. These are the south cable-bent pier, No. 18, and the two main tower piers, Nos. 19 and 20. The other 30 water piers were built in open cofferdams, either rectangular or circular, constructed with steel sheetpiling internally braced with steel frames. For the rectangular cofferdams, Z-shaped sheeting, bolted to one or more of the upper frames, was used. For the circular cofferdams, straight-web sheeting was used; this was designed to take the hoop tension resulting from grouting under water above the overburden level. Cofferdams were used even at Pier 13, where the depth of water was 82 ft; at Pier 33, where the depth of overburden to be removed was 36 ft; and at Pier 14, where the depth to rock was 101 ft.

The largest and most difficult cofferdam was constructed for the anchorage pier, No. 22 (Fig. 2). The base for this pier was a solid monolith 115 ft × 135 ft, extending from El. − 90.6 to El. + 10. The upper part, extending to El. + 122, was solid in the rear half and compartmented in the front half. The whole anchorage contained 85,000 cu yd of concrete and was designed to resist the pull from the two cables of 30,000 tons. The cofferdam bracing was fabricated and installed in three vertical sections, each weighing 107 tons. They were barged to the site, set by floating derricks, and bolted together under water by divers.

The cable anchorage was made up of carbon steel plates 26 in. × 1 in., anchored to girders at the rear of the anchorage. The weight of this steel was 170,000 lb for each anchorage. Lighter steel was placed near the top and in the front end of the anchorages to anchor the top chord of the 468-ft backstay span and give it a fixed end at the anchorage.

After the overburden had been removed with clamshell buckets and the rock surface had been cleaned with an airlift, light bridging was installed on the cofferdam frame, from which injection grout pipes and pipe sounding wells were suspended. A fleet of self-unloading vessels, each carrying about 10,000 tons of coarse aggregate, then started delivery and placement of the stone aggregate in the cofferdam. Each vessel, equipped with conveyors, could discharge its entire cargo in about 4 hours, or at the rate of 2,500 tons per hour.

After discharge of the first load of stone, the grout plant started operations. Batching, mixing, and pumping of the Intrusion mortar was done from a fully integrated plant mounted on one 50 × 150-ft barge. Equipment included a revolving crane with clamshell bucket for handling sand and pneumatic conveyors for handling cement and fly ash. This single plant had a capacity for consolidating concrete at the rate of 250 cu yd per hour.

Open-dredged caissons for main piers

Open dredged caissons were used for the south cable-bent pier, No. 18, and for the two main tower piers, Nos. 19 and 20, as previously mentioned. The caisson for Pier 18 was rectangular, 44 × 92 ft in plan, and was sunk 130 ft to rock. It was fitted with 21 dredging wells, each of 9-ft diameter. The lower 48-ft section was fabricated and assembled at the Toledo, Ohio, yard of the American Shipbuilding Co. and towed to the site.

For Piers 19 and 20, the caissons were double walled (Fig. 3), the outer one 116 ft in diameter and the inner one 86 ft in diameter. The inner shell was tapered down to meet the outer shell at the bottom to form a thin cutting edge. The 15-ft space between the two concentric steel shells was divided by radial diaphragms into eight watertight compartments. The opening of 86-ft diameter inside the inner shell served as one huge dredging well. The lower 48-ft sections of these caissons were assembled at the Alpena, Mich., shipyard of the Wiltse Brothers Corp. and towed to the site. Before towing, a small amount of rich, conventional concrete was placed in the cutting edge for ballast.

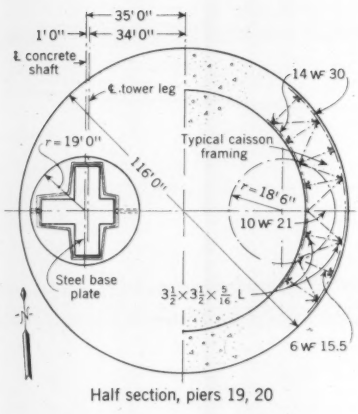
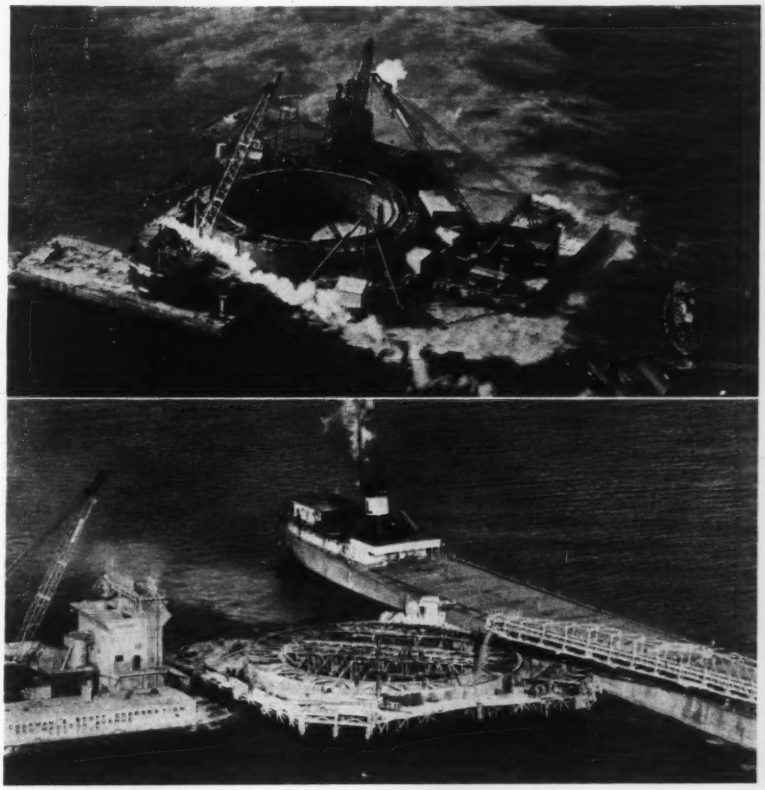


FIG. 3. Cofferdam for north tower pier was circular double-walled structure fabricated with eight watertight compartments. Walls tapered to cutting edge at bottom. Outer wall had diameter of 116 ft, and inner wall, of 86 ft. All concrete was placed by Intrusion Prepakt method, with aggregate varying in size from $^1/_2$ to 6 in. In photo at right (top), excavation is under way inside 86-ft dredging well of caisson. In photo below, self-unloader is placing coarse aggregate in caisson. Note corral for holding caisson in position, and interior bracing for support of injection grout pipes and surrounding wells.

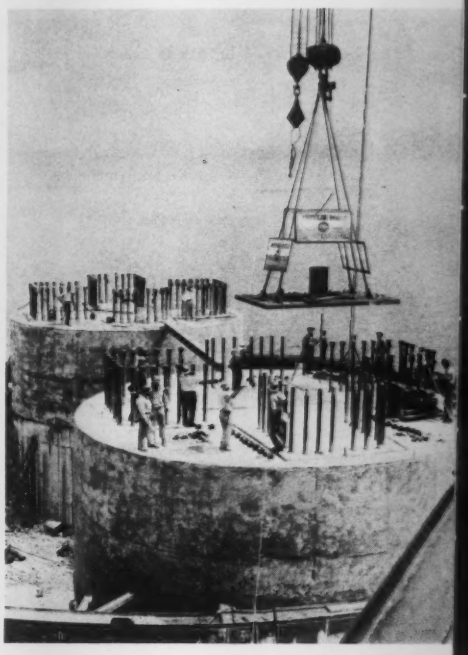
The caisson for Pier 19 was sunk through 140 ft of water and 66 ft of overburden a total distance of 206 ft to rock. At Pier 20 there was 96 ft of water and 105 ft of overburden. The caissons were progressively sunk by dredging, placing concrete in the compartments, and building up the caisson with prefabricated panels. The caissons were maintained plumb during sinking by varying the amount of concrete and the amount of water ballast in the various compartments.

Corrals hold caissons in place

During sinking, caissons were held in position by corrals instead of by the



Base of each tower leg on Piers 19 and 20 (below) is secured by 68 four-inch silicon steel bolts. Base plate for west leg of north tower is being lowered into place.



more conventional anchors and steel cable ties. The latter limit space for maneuvering floating equipment and are subject to the hazards of being fouled or cut by floating equipment. The corrals for the main tower piers were composed of four steel towers equally spaced around the circular caissons and connected with horizontal box-type trusses. Each of the four steel towers was made up of twelve pipes of 20-in. diameter, nine vertical and three battered, spaced 13 ft on centers each way. All pipes were rigidly braced together with horizontal and diagonal 6-in. pipe bracing, all connections being welded.

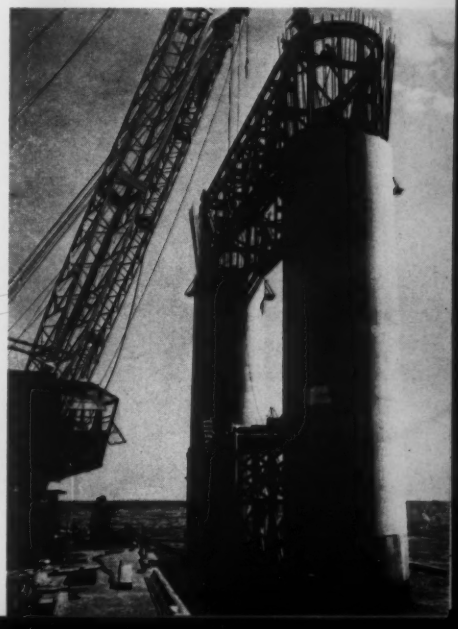
The heaviest corrals were required at Pier 19, where the water was 140 ft deep. Each of the four steel tower assemblies weighed 160 tons. The horizontal trusses connecting the tower assemblies weighed 80 tons, making a total of 720 tons for one corral.

Tower sections were assembled in the nearby yard, barged to the site, and lowered into position on the overburden. Then they were stabilized and supported by driving 12-in. 74-lb steel piles inside the 20-in. pipes to refusal. Additional rigidity was obtained by grouting the space between the pipe and the spud piles.

After three of the tower sections had been thus secured in place, the caisson was towed into position, the fourth tower section installed, and the corral completed by connecting tower sections with horizontal trusses. Each corral was built to provide about 1 ft of clearance around the periphery of the caisson to permit tilting of the caisson as necessary to keep the cutting edge accurately positioned at all stages of the sinking operation.

Caissons for Piers 19 and 20 were founded on rock, cleaned out, and equipped with grout pipes, ready for the first load of coarse aggregate in the center dredging well on April 29 and May 6, 1955, respectively. With these huge caissons and some cofferdams ready to be filled with Prepakt concrete, new world's records were established for underwater concrete placement from a single floating plant—6,250 cu yd in a single day and 103,107 cu yd in 30 days. Such rapid stabilization of open caissons

Cable bents on Piers 18 and 21 (below) are circular in section to reduce ice pressure. Pier bases were cut off at El. −8 to further minimize effect of ice pressure.

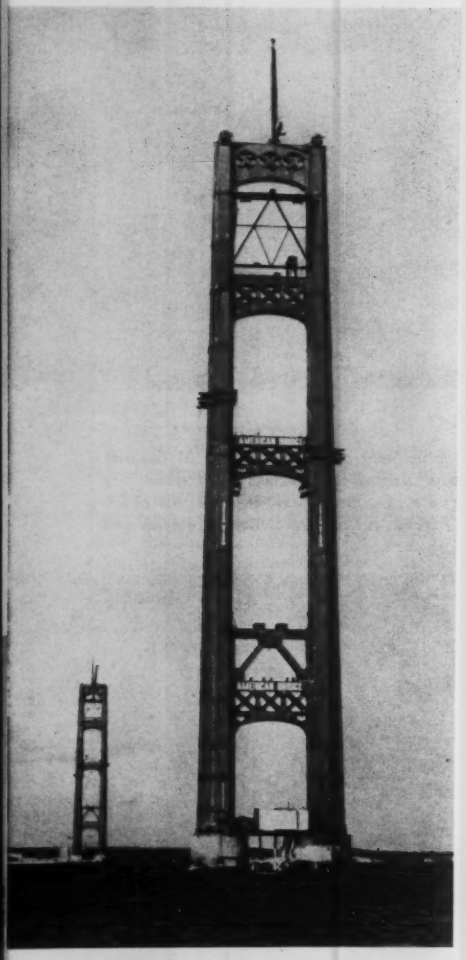


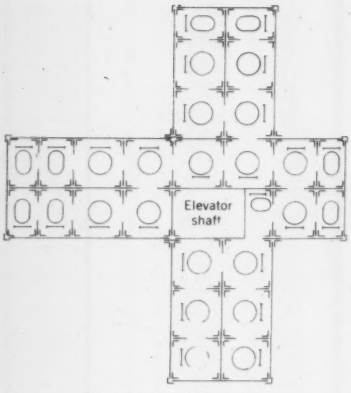
and cofferdams in open water is one of the features of Prepakt concrete.

All steel sheetpiling for cofferdams was left in place to add permanence to the concrete. At the anchorage piers Nos. 17 and 22, the sheetpiling was cut off at El. + 10, thus serving as armor against abrasion by ice. At all the other piers the sheeting or caisson was cut off at El. − 8 and the pier shafts were armored with $^3/_8$-in. wrought-iron plates from El. − 8 to + 10.

Bad weather holds up work

Extremely cold and windy weather in November 1955 was a severe handicap to the substructure contractor and required an early winter shutdown on December 1, whereas the previous year he had been able to work until January 14. At that time 94 percent of the substructure contract had been completed. Completion of the anchorages or 4 percent of the work, necessarily is scheduled for completion in 1957, after the cables have been spun and dead load added to the cables. The remainder of 2 percent remains to be completed in the early spring of 1956.





Typical horizontal section

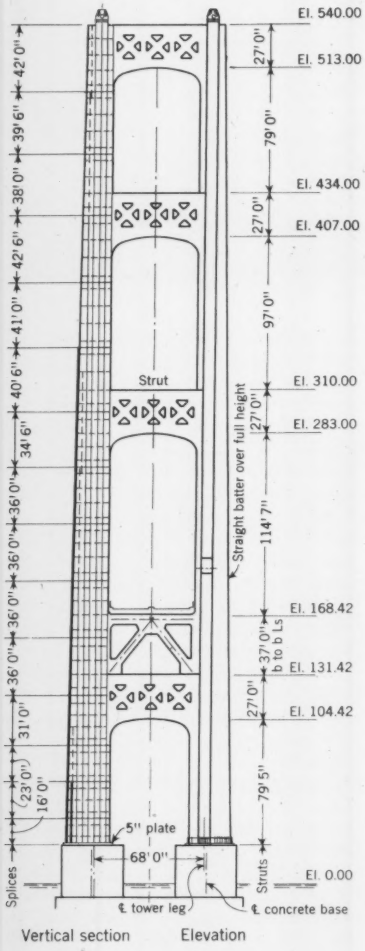


FIG. 4. Main towers, seen in vertical section and elevation, rise 523.5 ft above tower base. Typical horizontal section (at top) gives arrangement of openings and ladders. One leg of each tower is equipped with an elevator and each tower compartment is provided with a ladder. In photo, south tower is in foreground.

The two main steel towers for the suspension span are 523.5 ft tall, extending from El. + 25 at pier top to El. + 548.5 at the point of intersection of cable tangents (Fig. 4). These towers are of conventional cellular construction, flexible type and with fixed bases. The base of each tower leg was fixed by post-tensioning 68 silicon steel anchor bolts of 4-in. diameter, set in pipe sleeves of 6-in. diameter. One leg of each tower is provided with a service elevator and each compartment of each tower is provided with a ladder. At frequent levels, man-holes provide access to all compartments to facilitate access for inspection and painting.

Towers were designed as rigid frames to transmit lateral wind forces to the piers. Transverse bracing consists of three-web closed box sections, which are of open trussed appearance when seen in elevation. Ladders and manholes similar to those in the tower legs, were provided in the various compartments.

Each tower leg is cruciform in shape with each wing 7 ft 6 in. wide. The transverse section varies in length from 25 ft at the bottom to 14 ft 6 in. at the top. The corresponding lengths in the longitudinal direction are 30 ft 6 in. and 15 ft. Sections near the base were divided into four approximately equal parts for shop assembly and erection. Such sections varied in length from 16 ft at the base to 42 ft 6 in. near the top in order to limit the maximum lift to 48 tons for the three lower sections and to 80 tons for the sections above.

The three bottom sections, extending up to El. + 87, were erected with a floating derrick. The floating derrick then erected a creeper traveler on the side of the tower. Remaining sections of the tower were erected by the creeper as it was successively jumped to follow closely behind the newly erected sections. After the towers had been completely erected, including tower saddles, the creeper erected a stiff-leg derrick on each tower top for use in setting catwalks and spinning equipment. The creeper was then dismantled.

Erection of the two main towers was started in July and completed in December 1955. The weight of steel in the two main towers is approximately 13,000 tons. The cost of the towers was approximately $7,250,000, about 16 percent of the superstructure contract.

PNEUMATIC CAISSON PIER

for world's longest pipeline suspension bridge

JOHN N. NEWELL, M. ASCE

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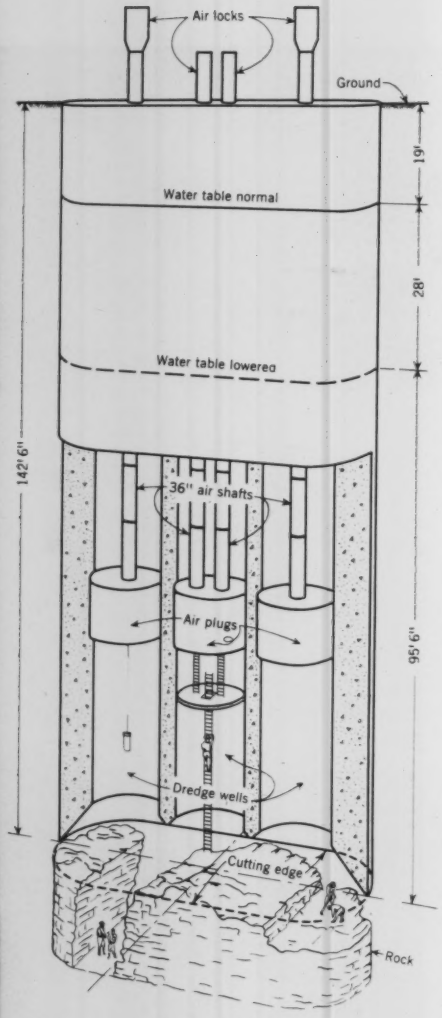
With its 2,150-ft main span, the world's longest pipeline suspension bridge completely jumps the Mississippi River at a clear height of 75 ft above the highest recorded flood. Located 80 miles below St. Louis, between Grand Tower, Ill., and Wittenberg, Mo., it carries two pipelines of 30-in. diameter for the transmission of natural gas. Its completion in the fall of 1955 at a total construction cost of $2,375,750, and a total project cost of approximately $3,250,000, insured an uninterrupted flow of natural gas across the Mississippi River for its owners, the Texas-Illinois Natural Gas Pipeline Co.

Including the 840-ft unloaded backstay on the Missouri side and the 700-ft unloaded backstay on the Illinois side, the bridge has a total length of 3,690 ft between anchorages. The accompanying photos, as well as that on the cover, show the magnificent sweep of this structure.

For a structure of this magnitude an adequate foundation is a matter of prime importance. In the vicinity, there is much visual evidence above ground of upheaval due to seismic disturbances—a condition which challenged the ingenuity of the best engineering consultants in determining the most favorable locations for the supporting piers and anchorages.

The subsurface investigation made prior to the award of any construction contract was extensive and thorough, and subsequent completion of the piers and anchorages proved the unusual degree of accuracy of the preliminary investigation.

On the Illinois side of the river, the presence of foundation rock at a shallow depth made it possible to found the main pier and anchorage in open steel sheetpile cofferdams. Consequently the Illinois pier and anchor presented no



problems of unusual interest. On the Missouri side of the river, however, conditions were very different. There bedrock lies under about 150 ft of overburden, making it necessary to found the anchorage on steel bearing piles driven to rock. The main pier on that side, however, was designed as a pneumatic caisson to be sunk approximately 150 ft to rock and to be sealed under air. The problems encountered in founding this pier make it a subject of unusual interest.

Test borings and studies made by the designing engineers indicated two conditions that would complicate the landing of the caisson under air. First, the existing ground-water table was close to the surface, approximately 145 ft above the deepest foundation rock. This would require air pressure in the caisson of 63 psi or 13 psi above the allowable maximum for pneumatic work. Some method for reducing this hydrostatic head had to be devised. Second, test borings indicated an unevenness in the surface of the foundation rock of about 17 ft within the boundary of the caisson's cutting edge. Also, borings indicated that the cutting edge would pass very near a rock ledge or face that projected up nearly 40 ft above the planned final depth. Such extreme unevenness in the surface of the foundation rock frequently gives trouble in landing a caisson at such depths.

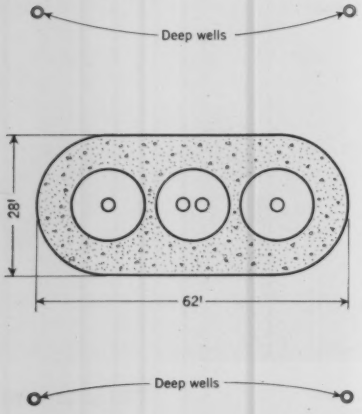
To keep the air pressure within the 50-psi limit, we installed four deep-well turbine pumps about equally spaced around the caisson and about 30 ft out from its exterior face. These were Layne-Western pumps of 3,000 gal per min each, and were equipped with 75-hp electric motors for continuous operation. Installation of the pumps was made by the Layne-Western Co. of Kansas City, Mo.

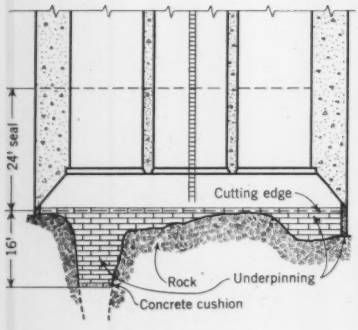
It was important that the pumps be set at the lowest possible elevation to pick up water near the rock surface. Using preliminary borings as a guide, an effort was made to locate each well so that a pump could be set in a crevice or low pocket in the rock and still maintain an effective well pattern. In some instances well locations had to be abandoned after drilling to rock when it was found that the well had landed on a high point. A change of only a few feet in location would result in striking rock many feet deeper, thereby giving a much better well for the purpose intended. Three wells were successfully installed at depths reasonably close to the final depth planned for the caisson's cutting edge. The fourth well landed in an area of generally high rock and was never effective in picking up ground water at the desired depth and location.

These wells were installed at an early stage of pier sinking so that their performance in lowering the ground water could be observed before they were needed for the pneumatic operation. It was expected that the ground water would be lowered about 50 ft by the four wells, thereby lowering the air pressure in the caisson about 22 psi. When the deep wells were first put in operation, the water table was drawn down 50 ft, but by the time they were most needed, they had suffered so much damage, as will be explained later, that their effective drawdown was reduced to about 30 ft.

The caisson was built of reinforced concrete with a welded steel cutting edge. Its plan dimensions were 62 ft by 28 ft with ends rounded on a 14-ft radius, as shown in Fig. 1. Three dredge wells of 14-ft diameter were formed in the concrete. A steam-powered revolving crane operating on a track along one side of the caisson handled all necessary hoisting and open-dredge excavation through the dredge wells. Concrete was added to the caisson above ground in 10-ft lifts, forms stripped, and open-dredge sinking performed in the conventional manner. The caisson was sunk approximately 125 ft by open-dredge excavation, at which depth air plugs were installed (see Fig. 1), and the remaining sinking done by pneumatic excavation.

FIG. 1. Caisson for pier on Missouri side of Mississippi River was sunk 142 ft 6 in. to high point in bedrock, first 125 ft by open dredging and final 17 ft under air. Cutting edge then had to be underpinned with concrete curtain wall extending down to irregular surface of bedrock. This proved most exacting part of a difficult pneumatic caisson job. Above is cutaway view of caisson, and below, cross section of caisson with location of deep wells and at right, arrangement of underpinning.





Effect of pumping on sinking

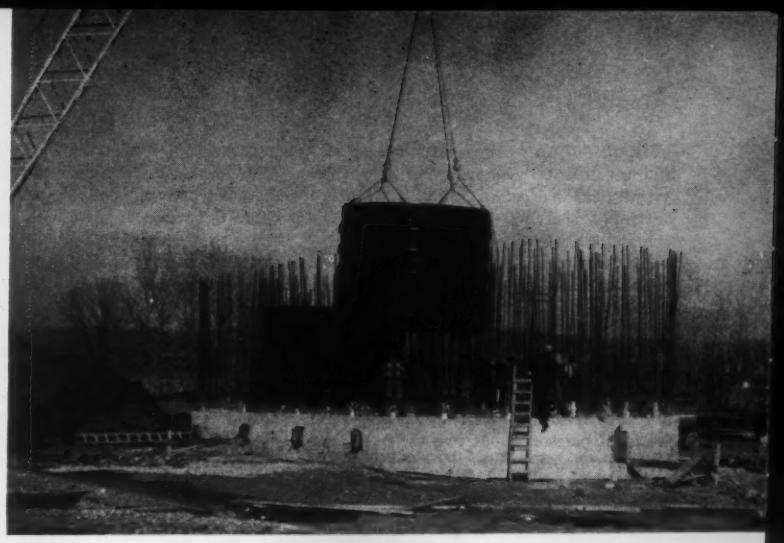
During the open-dredge sinking certain characteristics appeared that are worthy of note. The dry weight of the caisson was 166,000 lb per lin ft of height. Its weight submerged in water amounted to 97,800 lb per lin ft of height. The exterior skin area subject to friction from the surrounding overburden was 156 sq ft per lin ft of height.

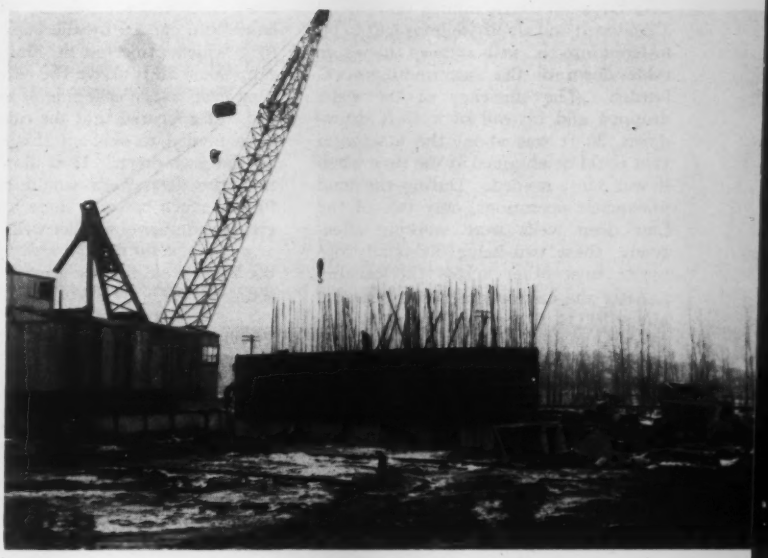
Hence the caisson weight per square foot of friction area amounted to 1,064 lb above the water table and 620 lb for the submerged part below the water table. The surrounding overburden was mainly fine to medium sand and silt.

Since the deep wells were expected to play an important part in reducing air pressure for final pneumatic sinking, these wells were put in operation at an early stage of the open-dredge sinking. This was done so that the drawdown of water in the caisson dredge wells could be observed, and conclusive proof obtained that the air pressure could be held within the 50-psi maximum when the time came to proceed with the final sinking and sealing.

It became evident that the operation of the deep wells had a definite effect on the friction against the exterior skin. Even though the smaller part of the caisson was submerged below the water table during open-dredge sinking, the operation of the dewatering wells effectively restrained the caisson from sinking. The well pumps could be turned off, and within a period of approximately 10 min the caisson would begin to sink. By starting up the pumps again, the caisson could be braked to a stop almost immediately. The run-in of sand in the working chamber at the bottom of the caisson during dredging was definitely reduced by operating the pumps.

While the pumps were on it was possible to dredge down to or below the cutting edge without appreciable sinking of the caisson. When the pumps were off, sand ran in and filled the working chamber, and the caisson settled more closely in direct proportion to the amount of material dredged. This behavior of the caisson's sinking in relation to the operation of the deep wells indicated that the variation in friction was due to lubrication of the sand by the





Most difficult part of foundation work was sinking caisson for main pier on Missouri side of Mississippi. In photo at top, forms are being set for dredge well of 14-ft diameter during early stage of open-dredge sinking of caisson. Note keys on forms which allow air plugs in wells to be cast at any desired elevation without danger of blowing out. In middle photo, taken 19 days later, track-mounted revolving steam crane is setting outside forms for 10-ft lift of concrete. Photo at bottom was taken during final phase of sinking—done under air. Sand and clay are being mucked out through side-door pneumatic muck lock. Similar lock is on far end of pier. Two man-locks are in center of caisson, protected by low tarpaulin.

addition of a comparatively small amount of water. Correspondingly, the withdrawal of a small amount of water definitely stiffened the sand and developed additional friction.

By the time the caisson had sunk 125 ft, mistakes in the installation of the deep wells became evident. Overburden surrounding the caisson had settled as a result of the run-in of material into the working chamber. This subsidence took the shape of an inverted cone, the boundary of the upper base extending out from the caisson about two-thirds of the caisson's depth, while its vortex probably coincided roughly with the caisson's cutting edge.

The deep wells, being located in the subsidence area, were subjected to so much lateral movement that it soon became impossible to keep the drive shafts to the turbine pumps turning. The Layne-Western pumps had to be abandoned and air-lift siphons had to be lowered into the wells to keep the water table down in the surrounding overburden. The efficiency of the wells dropped and instead of a 50-ft drawdown, 30 ft was about the maximum that could be obtained at the time when it was most needed. During the final pneumatic operations, only two of the four deep wells were working effectively, these two being diagonally opposite each other across the caisson.

After the caisson reached a depth of about 100 ft, it became difficult to control its lateral position, especially its tendency to skew. The south end held very close to correct position throughout the sinking, but the north end continued to move west throughout the final 50 ft of sinking despite all efforts to correct this movement. It is of interest to note that the north end moved almost continually towards the deep well located to the west of it, and this well pumped ground water effectively all during sinking. The well sunk to the east of the north end, as previously mentioned, landed in an area of high rock and was of no value in lowering the ground water. The two wells straddling the south end of the caisson both operated effectively and this is the end that remained very close to correct position.

It appears that the unsymmetrical pumping of ground water at the north end of the caisson influenced its movement toward the area where the ground water had been most effectively lowered. It can be argued logically that the caisson should move towards the dryer side, as it did in this instance; but also theory can be reasonably quoted to show that movement should be in the direction of the wetter side. Space here does not permit a detailed exposition of the two conflicting theoretical arguments.

The sinking of this one caisson, with its surrounding deep wells, did not give any conclusive evidence as to which direction unsymmetrical pumping would cause a caisson to move in. However there was positive evidence that the pumping materially increased the surface friction on the caisson's skin and reduced the amount of run-in into the working chamber. This phenomenon is noted here so that others who may have an opportunity to observe the influence of pumping on caisson sinking under similar conditions, will be forewarned and hence in a better position to analyze the problem.

There is a possibility that the influence of ground water, if properly understood and controlled, could be a factor in controlling caisson position during sinking on certain deep foundations. On this job, there was a possibility that the excessive movement of the caisson's north end towards the west could have been caused by the high ledge of rock which projected up almost vertically some 35 ft above the cutting edge very near to the east side of this north end. It appeared that the caisson may have tended to skid off this rock face on the way down. It is also believed that the deep wells would have performed much better if there had been a greater number of smaller wells installed at a distance far enough away to escape the zone of subsidence around the caisson.

Sinking under air

After sinking by open dredging about 125 ft, the decision was made to convert to air and complete the final 25 ft by the pneumatic method. It was hoped that the position of the caisson could be improved under air. During blow-pipe excavation and sinking, all known methods of improving its lateral position by pulling in excessive material under the east cutting edge, by water jetting along the east face and by employing timber kickers, were used. However the north end continued to move westward with each successive drop.

When the cutting edge had reached a depth approximately $5^1/_2$ ft above the final plan elevation, a horizontal fracture about 15 ft long developed in the wall of the west cutting edge near the roof of the working chamber. This fracture indicated a force tending to break the cutting edge inward. A ridge of foundation rock had been uncovered in the working chamber at this elevation extending roughly across the center of the chamber. The cutting edge had already landed on this ridge in two or three locations.

After considerable investigation, it was decided that, considering the tendency of the caisson to move laterally westward, further sinking might seriously damage the fractured cutting edge and actually impair the foundation strength of the completed pier. Therefore it was decided to stop sinking at this level and to finish the foundation by underpinning the cutting edge.

Caisson underpinned

Underpinning any pneumatic caisson at such a depth on an irregular rock surface is a very difficult operation. The actual underpinning consisted of constructing, in place, a continuous concrete curtain wall around the caisson from the cutting edge down to firm rock. This wall was constructed in increments consisting of concrete blocks poured in place about 2 ft high by 1 ft thick by 5 ft long.

Probably the most delicate step in the underpinning procedure was the opening up of the sand face under the cutting edge or under a completed course of wall. During this work, air pressure was stepped up to keep out water and prevent a possible blow-in. The vertical sand face was exposed in small increments of 1 sq ft or less and immediately plastered over with wet clay by hand. As the area was carefully enlarged to accommodate one 5-ft-long concrete block, one man constantly kept smoothing over the clay plaster by hand, dipping his hand in water and keeping the clay wet. Air pressure had to be maintained just high enough to hold the clay seal against the sand face. No hole could be permitted to open through the clay seal through which air could leak, and no water was permitted to bleed through the seal from the outside sand. After a 2-ft by 5-ft area was opened and sealed with clay, the face would stand intact for only a few minutes, during which time an inside wall form had to be set, some light reinforcing placed, and concrete shoveled in behind the form. Concrete usually was mixed and turned by hand close by in the caisson area.

The 5-ft blocks were constructed alternately around the perimeter of the cutting edge, then the skipped areas were filled in the second time around. First, underpinning blocks were constructed in areas where the cutting edge was on or near sound rock in order to get firm bearing on rock, thereby preventing any further sinking of the caisson, which would crush and destroy all the underpinning in place. Concrete takes initial set very rapidly under the warm, moist atmosphere of a pneumatic caisson. Alternate pouring of blocks and staggering of joints between succeeding courses allowed individual blocks to span across openings for blocks being constructed in the next course without sagging.

In any caisson where underpinning is anticipated, holes should be provided

in the steel cutting edge, or some other similar means provided to permit the hooking of vertical reinforcing steel and hanging it from the cutting edge. This is a valuable aid in making certain that the underpinning concrete will not sag away from the cutting edge while excavation for lower courses is under way. Any attempts at welding or burning on the steel cutting edge under pneumatic pressure should be avoided, but if they are unavoidable, extreme precautions against fire should be taken in the compressed, heavily oxygen-laden atmosphere.

After a course of underpinning was completed, the working chamber was cleaned out to the lower elevation allowed by this extended curtain wall in order to start the next course. Air pressure then was increased accordingly, and the next course constructed. This cycle was repeated until the underpinning wall was completed down to sound rock around the perimeter of the caisson. Finally foundation rock within the limits of the underpinning was cleaned off.

During the underpinning work, a fault or crevice about 10 ft wide was uncovered in the rock extending across the south end of the caisson as shown in Fig. 1. The underpinning walls followed this fault down to a depth of 16 ft below the cutting edge, at each side where the cutting edge crossed it. No attempt was made to reach the bottom of the fault because of the great hazard of a blow-in and because we were approaching the 50-psi limit of air pressure. We found that the underpinning operation increased the demand on our air plant about 40 percent. Approximately 3,000 cfm of air was being used in the caisson during the underpinning operation.

To place the final seal in the caisson, it was necessary to drop the concrete about 170 feet through the bucket locks in free fall. It was realized that the sharp impact of the concrete striking bottom might result in a blow-up of the unexcavated sandy-clay fill in the rock fault. This could have caused the failure of all the underpinning in place. To guard against this, a reinforced concrete slab 1 ft thick was carefully hand placed on the entire bottom of the fault excavation to act as a cushion. The concrete seal was then poured to a height of approximately 24 ft above the cutting edge. Next the caisson was capped above ground and the pier completed.

Matthews & Kenan, consulting engineers, San Antonio, Tex., were the engineers for the project, and Mitchell & Hunt, consulting engineers, San Antonio, Tex., were Associate Engineers. The bridge substructure was constructed by the Massman Construction Co. of Kansas City, Mo. The bridge superstructure was fabricated and erected by the American Bridge Division of U.S. Steel Corporation.

(This article was originally presented by Mr. Newell as a paper at the ASCE Dallas Convention, before the joint session of the Construction and Structural Divisions, presided over by Maurice N. Quade, a member of the Structural Division's Executive Committee.)

Gas pipeline jumps Mississippi River on clear suspended span 2,150 ft long. Two lines of 30-in. diameter carry fuel for Texas-Illinois Natural Gas Pipeline Co. In air view taken from Missouri side, difficult pier is that supporting main tower on near side of river.

OUR FEDERAL GOVERNMENT appraised by the Hoover Commission

Economy and efficiency demand major reforms

S. C. HOLLISTER, M. ASCE

Dean, College of Engineering, Cornell University, Ithaca, N.Y.; Member, Second Hoover Commission

In a quarter-century we have witnessed an accumulation of bureaucratic power which is the largest and the most costly the world has ever seen. The current annual cost of the Federal Government amounts to an average of about $1,300 per family. It is high time that all citizens took an active interest in their stake in government.

On July 10, 1953, the President approved Public Law 108 of the 83rd Congress providing for the establishment of the Commission on Organization of the Executive Branch, known as the Second Hoover Commission, which made its final report on June 30, 1955.

Charged with the responsibility of looking not only at the structural organization but also at the function and policies of the several agencies, this commission made the most searching examination of the Federal Government since the Constitutional Convention of 1787. Of course only a few examples of its findings, of special interest to engineers, can be mentioned here.

After the First World War there was a shrinkage in the size of government. After the Second World War, however, there appears to have been no such shrinkage. On the contrary, there is every indication that many agencies are trying to continue the prodigious expansion of recent years.

To get some notion of the problem of control, consider the inventory situation. The Federal Government owns one-quarter of the land area of the continental United States, but there is no currently maintained land inventory. The result is that new acquisitions of land are being made without any realization that nearby is government-held property that would suffice.

The Federal Government's depot system comprises about 50 sq miles of space, the portion under cover amounting to more than the area of Manhattan Island. Not only was it found that there was not an adequate inventory of this storage space, but 100 million sq ft, or over 2 thousand acres of it was not even listed on operating records.

It was further found that there was no adequate inventory of common use goods. It took the Department of Defense eight weeks, and eight federal civilian agencies from 3 to 11 weeks, to find out whether they had 12 items of common-use goods on hand.

The same situation holds for property other than real estate. Here is an example cited by the Task Force on Surplus Property. The Navy decided in 1949 to reclaim pig lead from scrap metals on hand, and over the next four years accumulated 18,000 tons of pig lead, worth about $5.3 million. This lead was not offered for possible use to other agencies, and was even retained during a period of maximum shortage of lead in the national economy. Had it been diverted to the economy it would have been re-allocated by the National Production Authority, and the Navy would have received its fair share in case it had need for it. At the same time the General Services Administration was accumulating a national stockpile. The Navy would not transfer it to GSA for nothing and GSA would not pay the Navy anything for it, so it did not get into the stockpile. Army Ordnance was in need of lead wire and lead in other forms requiring an addition of antimony. It rejected the Navy lead, to which the antimony could have been added, and instead went into the open market and bought 5,000 tons of lead wire and other things for $1.5 million, although a general shortage of lead existed.

The Commission believed that great savings would result from better inventories, better procedures for screening excess and surplus property, and a different system of budget structure. By improved methods of disposal of surplus, it is estimated that for the first four years about $2 billion a year could be recovered by the Treasury, and that thereafter an annual recovery of about $1 billion would be possible.

One of the most impressive findings was the extent to which the Federal Government is operating commercial and industrial facilities. It is impossible to make an accurate estimate, but it is believed that there is a total of over 3,000 such facilities, and in the Department of Defense alone, over 2,500—with government capital invested probably exceeding $15 billion. In general these facilities are operating in competition with privately owned commercial con-

Terming the work of the Second Hoover Commission the most searching examination of the Federal Government made since the Constitutional Convention of 1787, S. C. Hollister, M. ASCE, a member of the Commission, summarizes results of the investigation of special interest to engineers. However, he leaves the findings of the Task Group on Water Resources and Power to be discussed by its chairman, Admiral Ben Moreell, Hon. M. ASCE, whose article follows his. Both articles are abstracts of the papers presented by these distinguished members of ASCE at the Second Annual Assembly of Engineers Joint Council, held at the Statler Hotel, New York, January 26 and 27, 1956.

cerns. These concerns pay taxes which the Government then uses to compete against them.

As an example of conflict of function, in fiscal 1954 the Government operated a fleet of 221 ships to carry freight and passengers. These ships often operated on lines paralleling those of commercial shipping companies which received Government subsidies in order to maintain an American Merchant Marine. In the same way, the Federal Government operated air transport service costing nearly a half billion dollars annually and flying routes paralleling commercial lines to which the Government was paying subsidies in order to build up our transport system.

Another example shows the competition of interests between different parts of the Government. In these times of enormous agricultural surpluses, purchased and stored by the Federal Government to sustain agricultural prices, other parts of the Government are asking for appropriations with which to extend agricultural output through the extension of irrigation. They propose doing this at the fantastic cost to the taxpayer of nearly $2,000 per acre.

In the whole area of Government-operated business enterprises, the Commission found repeated claims of lower cost through Government operation. Again and again, however, the Task Forces looking into these matters found that underlying the so-called low cost of goods and services was an inadequate accounting system that did not include all the costs. Take the Military Sea Transport Service, for example, which operated 221 ships in 1954, carried over 2 million passengers and about 3 million tons of cargo including petroleum products. The operating costs were stated to be $549 million for the year. The Task Force, however, points out that these estimated costs did not include the military pay and retirement allowances of certain personnel involved, did not include depreciation, interest on investment, taxes and other items, which the Task Force calculated would add at least 20 percent to the total cost.

Competition of this type between Government agencies and private enterprise becomes increasingly unfair with the increased income taxes now being imposed on corporations and private individuals. In effect the Government is busy actively promoting the killing of the geese that lay the golden eggs.

A major problem created by the sheer size of the Executive Branch is its overall management. There are 64 executive agencies, all of which report to the President. It is physically impossible for him to manage these agencies, and yet it is evident that closer management is essential. The President has direct responsibility for 31 of them. The remaining 33 could, in the Commission's opinion, be placed under the direction of an executive designated by the President who would manage them in his name, thus considerably lightening his load.

A considerable amount of aid to the President should be given in the area of budgeting and accounting. The task Force on Budgeting and Accounting stated that under present procedures "there is no effective control for expenditures either by the Congress or the Executive Branch." Under present procedures of budgeting and appropriating for obligational authority, huge unexpended appropriations are carried forward from year to year, running as high as $78 billion for fiscal 1954, $68 billion for fiscal 1955, and an estimated $54 billion for 1956. The Task Force believed that reforms in budgeting procedures would make possible a saving of $4 billion a year.

The Commission points out that Congress enacts legislation for undertakings which leave the appropriations committees little discretion as to the amount to be appropriated. The Commission recommends that legislation committing the Government to continued expenditure for special programs not susceptible to the usual budgetary control, ordinarily be enacted for a limited term in order to require periodic Congressional review.

The Federal Government has undertaken responsibility for all or part of the medical care of about 30 million of our people at an annual cost of over $4 billion. Ninety percent of this service is in the Veterans Administration, Department of Defense, and Department of Health, Education and Welfare.

Of these 30 million persons, 4 million, mostly on active military duty, and $3\frac{1}{2}$ million veterans with service-connected disabilities, are entitled to complete medical care. About 20 million people are eligible for care on a facilities-available basis. Of this number, $17\frac{1}{2}$ million are veterans with no service-connected disabilities who are eligible for free hospitalization on their statement of inability to pay. About 2.9 million are dependents of military personnel. Retired military personnel make up most of the balance of the 30 million.

Currently the Federal Government employs about 10 percent of all active physicians, 9 percent of all active dentists, and 6 percent of active graduate nurses. The federal hospitalization amounts to 7.3 percent of all hospital admissions.

The Commission was very emphatic in its endorsement of full medical services to disabled veterans. It expressed concern however over the lack of cross-servicing in military hospitals and the fact that although over 60 percent of the beds in the Department of Defense were unused in 1955, over $60 million was being spent for new construction of hospitals. Also, in the Veterans Administration, with about 25 percent of the beds in general hospitals unused, further construction is being carried on.

The veteran's statement of his inability to pay his hospitalization, when such hospitalization does not arise from

service disability, is not under the law subject to verification. In an investigation by the Medical Task Force of 336 declarations of veterans with annual incomes of $4,000 or more, one had an income of $50,000; 25 had assets of $20,000 or more; and 4 had assets between $100,000 and $500,000. The Commission recommended that all such statements of inability to pay should be subject to verification by the Veterans Administration.

The Commission further recommended that a veteran should assume a liability to pay for care of his non-service-connected disability. If one looks ahead, with the constantly rising number of veterans, one can see that the net effect of the Federal Government's present obligation to render medical service is to furnish in fact a system of socialized medicine. In 1954, 60 percent of the 109,000 beds in the VA on an average day were occupied by non-service-connected cases. In 1953 in military hospitals 70 percent of the beds were occupied by the dependents of military personnel.

Recently in the press it was reported that the Veterans Administration is unwilling to adopt the major recommendations that were made by the Commission. No bureau wants its operations curtailed.

I have not mentioned the seriously disturbing outlook in federal participa-

Searching recommendations on

BEN MOREELL, HON. M. ASCE

The Second Hoover Commission, authorized on July 10, 1953, differed materially from the First Commission of 1947. The First Commission was far less of a political irritant than the second since it was concerned primarily with the shrinkage, reshuffling, and consolidation of agencies. The second was authorized, further, to recommend the *elimination of functions*. This involves not only abolishing jobs, but also reducing or canceling subsidies and grants. We were certain that when such measures were proposed, the voice of the anguished would be heard in the land. When pet projects are attacked, the time-honored tactic of demagogues and pleaders for special privilege is to assail the integrity and competence of the attackers. In view of the repeated assaults on the Task Force members, let me state who they were and how they were picked.

First, it was agreed that we should have geographical dispersion of membership; also, that there should be no representatives of either public or investor-owned power or other special interests. It was specified that all should be prominent members of their respective communities, men of unassailable integrity; and that they should be in the top ranks of their respective professions. No inquiry was made as to their political affiliations.

They were recruited from twenty different states. Professionally 14 were engineers, 6 lawyers, 2 newspaper publishers, 3 present or former state governors, 4 business executives, one consultant in utility economics and finance, and one accountant. This totals more than 26 because some members fall in more than one category. Two were former presidents of the National Reclamation Association, and three have served as officers in the Corps of Engineers of the Army. A number have worked closely with the Corps of Engineers and the U. S. Bureau of Reclamation, and several were at one time employed by the Bureau. A rough calculation indicates that, as a whole, they had spent considerably more time working for public agencies than for private industry. Eleven are members of ASCE and 9 served on the National Water Policy Panel of the Engineers Joint Council.

With the cooperation of the federal agencies concerned, some 200 projects were studied in detail. These included every reclamation project and every federal power system. Important examples of flood control and navigation projects, adequate to present a cross-section of these programs, were also studied.

Since 1824, when the Federal Government first started to develop our water resources, it has spent a total of $14.3 billion, of which $11.6 billion was for capital outlay and the rest for planning, maintenance, and operation. Projects already authorized call for an additional capital outlay of $18.5 billion. Other projects now in process of authorization or under consideration total $52 billion. Thus, with no allowance for cost increases, which experience indicates always occur, the total water resources program—built, building, authorized or contemplated—amounts to $82 billion.

The rate of expenditure is significant. From 1824 to 1920, nearly a century, only 8 percent of the present $14.3 billion total had been spent. Between 1920 and 1930, 6 percent was spent. And since 1930, 86 percent of the spending has taken place, with the bulk, 68 percent, mostly in the postwar years. The current performance indicates that unless something is done to decelerate it, the rate will continue to double about every ten years.

I believe the most important conclusion of the Task Force is that the activities of the Federal Government in this vital and costly field have grown like Topsy, with no central supervison except a "once-over-lightly" by the Bureau of the Budget. Huge sums have been spent without benefit of any clear-cut, unified body of federal policy. Each agency established its own policies

tion in water resources and power. This subject is being dealt with [in the following article] by the distinguished chairman of the Task Force on Water Resources and Power, Admiral Ben Moreell.

Summing up the benefits to be achieved through the adoption of the recommendations of the Commission, estimates have been made to indicate a saving of something like $6 billion annually with perhaps $10 billion of recaptured invested capital that could be returned to the Treasury. At any rate, the savings would be sufficient to balance the budget and to permit a reduction in federal taxes or a reduction of the national debt.

But money and efficient management are not all, or even the most important part of the story. The Government, whether intentionally or not, has embarked on business enterprises, on the nationalization of power, on socialized medicine. Is this the way the people want to go? The reports of the Commission present these problems and suggest cures.

None of the reforms recommended by the Commission will come about if the citizens of the country sit complacently on the side lines. We have the biggest and most expensive Government in the world. We are on trial to see whether we can make it effective without allowing it to become our master.

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water resources and power

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Chairman Task Group A, on Water Resources and Power, Second Hoover Commission

and, within each agency, there are different policies for different types of development. The current federal policies, taken together, are a hodgepodge of contradictions which generate conflicts among agencies, overlapping of functions, competition for position, and wasteful expenditures.

I shall mention very briefly some of our other conclusions.

First, federal power, which is important for two reasons: (1) because left-wing groups have found this issue has a strong popular appeal which can be used as a powerful political vehicle; (2) because socialized power can easily lead to socialized industry. There is no logical reason for the popular appeal of the federal power issue. Actually, the cost of electric power to the average householder is about 1 percent of his family budget. A reduction of only 3 percent in his tax bill would pay for all his power.

Technically and financially, there is no present or prospective need for federal power activities. There is no lack of ability on the part of private power to finance and install needed generating, transmission and distribution facilities. The figures refute the allegation that public power is essential for national defense. I had the responsibility for obtaining large quantities of power and many other things during the recent war. I do not recall that I ever felt dependent upon government production for anything.

All federal power is subsidized, more or less. The subsidy takes one or more of the following forms:

1. Interest rates lower than the actual cost for long-term money
2. No charge for interest during construction
3. No federal income taxes or comparable contribution to the cost of the Federal Government
4. No state and local taxes—with two minor exceptions
5. Charging large parts of the initial capital costs to wholly subsidized federal activities such as flood control, navigation, fish and wildlife, etc.
6. Charging administration costs, insurance, and pensions to other government accounts.

We found that if all federal power rates had been based on power values computed in accordance with Federal Power Commission methods (as applied to private producers), the rates would be increased by 30 to 50 percent and the Government would have received $130 million more in power income in 1953 alone. If present federal rates are continued for power projects now programmed, this revenue loss—which in its effect is a subsidy—could amount to $400 million a year.

This may seem a modest sum in these days of $65 billion federal budgets, but there is another important effect of such subsidies. They are possible only by diversion of other peoples' taxes. These and other handouts are bought with our votes which means, ultimately, with our freedoms.

Our Task Force concluded that no additional federal projects which are exclusively for power should be built and that an early start should be made on selling federal power projects or the power portions of multi-purpose projects to private industry or, if this is not feasible, to state and local governments.

Wasteful water use

Another important conclusion is that, in many instances, politically motivated development of our water resources has resulted in permanently committing precious water to uses which are uneconomic and wasteful. The much-discussed Upper Colorado River Storage Project is an outstanding example. Here is a project to develop power at localities far from where it is needed and to commit water to irrigating lands useful, for the most part, only for the growing of forage crops.

Political motivation clearly outbalances any economic consideration. Once water is committed to agricultural

uses, even though they be wasteful, it would be political suicide to try to take it away. There are vast deposits of oil and oil shales, coal, uranium, titanium, and other minerals in this area, as well as other industrial potentials, all of which will need much water for their development. It has been estimated that a thousand gallons of water will grow ten cents worth of crops but would permit the production of five dollars worth of industrial products. The first increment of this project, now being actively processed through Congress, is estimated to cost $1.6 billion, more or less, and the ultimate cost of the complete project, $4 to $6 billion.

We found that there has been great reluctance on the part of government to make people pay for the benefits they receive. In irrigation, the general range of payment required from beneficiaries has been between one-quarter and one-third of the capital costs, and a few are as low as 10 percent. In no case have they been required to pay interest. Some projects have a payout period of as much as four hundred years. With a few notable exceptions, flood control and navigation projects receive only token contributions from beneficiaries.

We conclude that the Federal Government has planned, constructed, and paid for projects which are economically unsound and, hence, waste the national wealth; that project costs are frequently underestimated; that estimated direct benefits are often exaggerated; and that unsupported and unsupportable claims are made for so-called "indirect benefits," such as, for example, tax revenues resulting from increased business activity, increases in the population, and many other credits claimed as resulting from the project.

This overestimating of "indirect benefits" is a favorite maneuver of the promoter of unsound projects.

Objectives of recommendations

The recommendations of the Task Force cover 25 pages and total 57 principal items. The first objective of our recommendations is to define a consistent federal policy for water resource and power development to the end that centralization of authority in the Federal Government shall be lessened, local authority and participation strengthened, and competition with private enterprise eliminated.

The second objective is to assure that uniformly consistent and sound principles and criteria be applied in determining what projects, involving the federal interests, would increase the national wealth and to determine whether or not state and local interests are willing to shoulder financial and administrative responsibility commensurate with the benefits they are to receive.

The third objective is to strengthen congressional control over water resources and power programs by establishing a central responsibility and authority that would enforce consistent policy and assure the technical soundness, the economic justification, and the financial feasibility of plans and projects proposed by the various agencies and by local entities.

What is the basic responsibility of the Federal Government for conservation and development of water resources and power? To the extent that these activities are essential to provide for the national defense, to preserve the national domain or to regulate interstate and foreign commerce, the federal responsibility is basic.

Applying these principles, the Federal Government should have responsibility for the protection and development of the Nation's port channels and its interstate and international waterways that are navigable in fact, wherever such port channels or waterways have a direct substantial significance for interstate or foreign commerce. The Federal Government should have responsibility for any other water resource development which affords substantial direct benefits to federal property.

The Federal Government, together with non-federal agencies and private citizens, should have joint responsibility for developments in the fields of flood damage abatement and reclamation which have substantial beneficial significance of national scope. While non-federal interests should have responsibility for initiating and administering such developments, the Federal Government should, *as an interim procedure*, continue to pay part of the cost of such projects. But the federal share should be gradually reduced to the point where it is representative solely of the direct and ascertainable national benefits produced.

Since an immediate change to the ultimate objective might be unduly disruptive to the economy, our Task Force recommended that, as a first step, such beneficiary groups should be required to pay at least 50 percent of the cost (including interest) of providing the benefits they receive. This would establish a single standard for flood control and reclamation calling for beneficiary payments approximately equal to what basic reclamation law now provides. Actually, the law has been largely nullified by frequent exceptions. We believe that once the people directly benefited are required to pay a significant part of the costs, politically motivated and economically unsound projects will be eliminated, or at least greatly reduced.

Non-federal agencies and private citizens should have basic responsibility for power development, water supply, pollution abatement, recreation, fish and wildlife conservation, watershed treatment programs, and other fields of water resource development not previously mentioned.

Coordination, not control

The Federal Government should cooperate in the coordination of planning but it should approach coordination "with a loose hand and a tight purse." In general, the federal responsibility will have been discharged if non-federal agencies are organized into appropriate groups that are competent to carry forward needful planning. Provision should be made for coordination between planning groups where a problem overlaps two or more areas. No attempt should be made to blanket the Nation with a preconceived group of planning areas; they should be formed as the need evolves. Separate operating agencies should not be set up for each planning area. In brief, the Federal Government should be the coordinator but it should not seize control.

The Task Force considered the following question: What steps should be taken to assure a greater measure of control by economic factors as opposed to political factors?

Briefly, we recommended that Congress establish a specific code of principles and procedures for determining the economic justification and financial feasibility of all water resource projects and that all agencies of the Federal Government should be governed thereby.

We recommended, also, that planning should be decentralized to local, state and regional groups of non-federal entities who should participate in financing. We found that one of the best practical tests of economic soundness is the extent to which the immediate beneficiaries are willing to spend their own money for the alleged benefits.

We recommended the establishment in the Executive Office of the President of a Water Resources Board which would resolve conflicts between federal agencies, establish uniform procedures and insulate the planning and construction agencies from political pressures. We recommended, also, an independent Board of Review to be established in the Bureau of the Budget to screen all project proposals made by the Water Resources Board.

That, in brief, outlines the ideas of the Task Force on what a federal water resources and power policy should be.

Double-cantilever hangar encloses 3½ acres

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Air Force engineers, facing the necessity of housing huge intercontinental bombers, have adapted an old principle to the needs of the atomic age. The result is greater horizontal and vertical clearance for aircraft than has been achieved in previous Air Force hangars.

The principle that made the outsize hangars possible is the cantilever, used in bridge building for more than a century, but applied in the hangar design with a difference. Through the middle of the building, running lengthwise, are a pair of longitudinal trusses supported on columns at their ends. Perpendicular to these longitudinal trusses are the cantilevered roof trusses, which project in both directions from their center supports, in some instances as much as 93 ft. This design made possible a new type of hangar, known in the Air Force as the "double-cantilever," a type now being constructed at long-range bomber bases throughout the nation. A number are going up in the Southwest, particularly in California, where several are scheduled for completion this year.

One hangar has more than 2 acres of usable floor space. Another, which can accommodate five B-36's at one time, covers 3.5 acres. Two smaller ones are under construction on other California bases, and plans for future construction call for two more. These hangars cost from two to four million dollars each, depending on their size.

Cantilever construction

Classical cantilever construction consists of horizontal beams or arches supported and counterweighted at one end. The same principle is used in the new hangars, but two sets of great steel trusses under the roof are anchored at the walls. Vertical columns provide additional support, and extra bracing guarantees against sway.

The selection of the type of hangar for any given Air Force base and its design is influenced by the following considerations:

1. Type of aircraft to be serviced, and degree of maintenance and repair work to be performed.
2. Degree of permanency desired and amount of funds available.

Planes serviced by the hangars are the newest and largest of Air Force bombers: B-47, B-52 and B-36. Crews can fly bombers such as the B-47 two to three days at a stretch, refueling only in the air from their KC-97 tankers. Complete overhaul and maintenance facilities must be available when such a trip is completed.

The double-cantilever hangars are being constructed at Strategic Air Command bases, the sites being selected because they fit SAC's operational requirements. They are permanent bases of the Air Force, and accordingly, when the Air Force began designing the double-cantilever hangar, permanency was an accepted factor.

In the design phase, the double-cantilever hangar presented formidable problems. It was important that storage, shop, and office space be readily available in the hangar to assure efficient and economical operations. Yet the interior of the hangar had to have a maximum of clear, usable space, requiring that support columns be kept to a minimum. Also, it had to be built as inexpensively as possible.

From a study of these requirements, the cantilever type of roof construction, with no supports along the outer walls, was chosen. Several different combinations of framing were investigated. Because preliminary tests proved it to be the most economical for this type of permanent construction, steel was chosen for the structural frame.

As soon as the general conformation and positioning of the trusses had been agreed upon, the practicability of using continuous trusses for the longitudinal members was studied. The character of the soil at most of the bases under consideration made it probable that there would be some settlement and that such settlement would be unequal. This led to the choice of simple trusses for the main members, a choice that proved to be particularly applicable at one of the California sites, where a special soil problem was encountered. The soil in this area consists of an old alluvial deposit made up principally of alluvial silt and black clay, or adobe. Test borings disclosed soil conditions which varied greatly in a longitudinal distance of 100 to 200 ft. One end of the 270-ft × 350-ft hangar, and the parking apron at that end, are built on

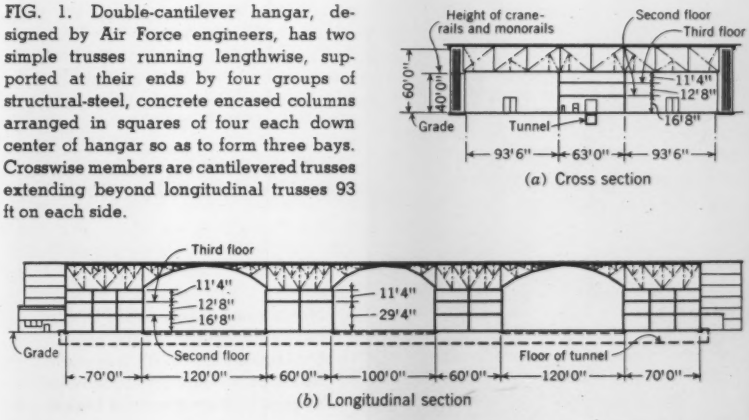
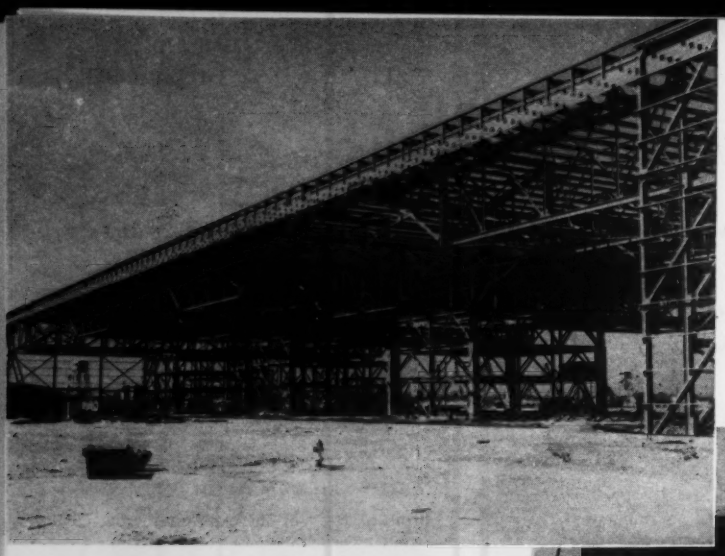
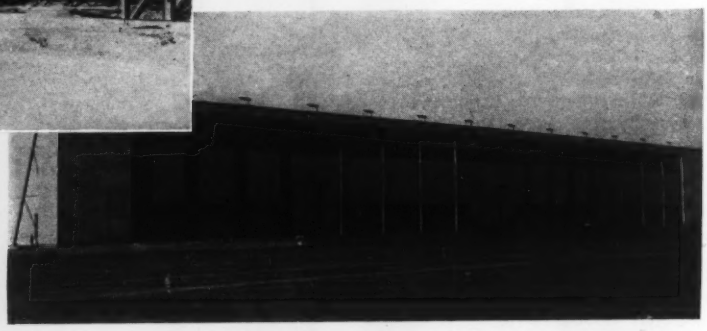
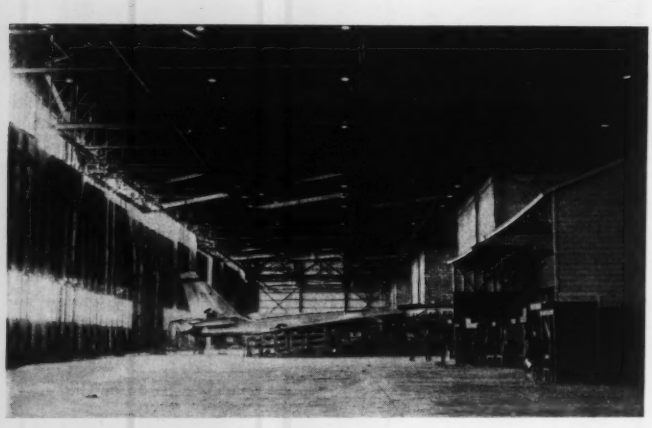


FIG. 1. Double-cantilever hangar, designed by Air Force engineers, has two simple trusses running lengthwise, supported at their ends by four groups of structural-steel, concrete encased columns arranged in squares of four each down center of hangar so as to form three bays. Crosswise members are cantilevered trusses extending beyond longitudinal trusses 93 ft on each side.





Roof-truss construction is based on principle of the cantilever for economy and to provide maximum clear space. Each group of four supporting columns forms a three-story unit for shop and office space. Completed hangar appears at right.



Hangar which can accommodate five huge B-36's at one time covers $3\frac{1}{2}$ acres. Floor consists of 14-in. concrete thickened to $17\frac{1}{2}$ in. at expansion joints. A B-47 Stratojet medium bomber is being repaired.

Mobile cranes place one of 18 door panels for hangar. Each panel is $6\frac{1}{2}$ stories high (66 ft), is operated by a separate motor, and controlled by push buttons at ends of hangar.

sandstone. At the other end, the engineers had to excavate through 8 ft of alluvial deposit.

The double-cantilever hangar which has now been completed at a Northern California site is the largest. It incorporates 184,320 sq ft, and is capable of housing and providing maintenance facilities for five B-36 bombers at one time. Since the building is 600 ft × 250 ft, it incorporates 3.5 acres of floor space—or room enough for four football fields.

Since a standard Air Force design is used for all double-cantilever hangars, construction procedures employed during erection were essentially the same. Problems encountered were found to be very similar to those experienced at other bases.

Actual construction of the 600-ft × 250-ft hangar started in January 1953. All work was completed and the hangar accepted by the USAF in January 1955, at a total cost of $3,445,660.

The Kuljian Corporation of Philadelphia was the architect-engineer and the T. C. Bateson Construction Co. of Dallas, Tex., the prime contractor. The San Francisco District, Corps of Engineers, was the construction agency for the U. S. Air Force. No delay was reported even though these agencies were located so far apart. Measures were taken to speed up the submission and approval of shop drawings, and work progressed on schedule.

Soil where the hangar was being constructed consists of what Californians refer to as "hardpan." It is a clay-silt which forms an almost impervious layer. It presents no special foundations problems, and simple reinforced concrete footings were used.

The main foundations are 22 ft × 22 ft, and the smaller footings 14 ft × 14 ft. To increase stability, the footings are tied together in a longitudinal direction by 3-in. steel rods, with turnbuckles buried under the hangar floor. Trans-

versely they are tied together with reinforced concrete beams, 3 ft wide and 4 ft deep.

Sixteen structural steel, concrete-encased support columns hold up the 3.5 acres of roof. These columns are grouped in blocks of four down the center of the hangar, one group at each end and the other two spaced an equal distance from the end ones. The four groups separate the hangar into three bays, providing maximum clear space for maneuvering and maintaining aircraft.

The hangar floor is of portland cement concrete 14 in. thick, with edges thickened to 17½ in. at the expansion joints. In the floor slab, 6,600 cu yd of concrete were used. Asphaltic concrete parking aprons 300 ft × 600 ft were placed in lanes on both sides of the hangar. The Concrete Supply Company of Merced furnished all concrete materials and put in both the hangar floor and the parking aprons. Regular runway construction equipment was used.

The positioning of columns in groups of four made a natural place for the shop and office space required. The limited area within which the columns were to be erected made it impossible to consider this space for maintenance operations, so shop areas were built to fit on the inside of each group of columns. They are constructed of concrete block with reinforced concrete floors. Each area is 63 ft × 70 ft and three stories high, and each has a stair well, lavatory, and freight elevator. The elevators were fabricated and installed by the Elevator Service Co. of San Diego, Calif.

Erection of the hangar started on one side and progressed toward the opposite side. After the office and shop section was completed, the first two main columns were set in place and erection of the main trusses began. These trusses were shop assembled before shipment, and final assembly was accomplished in place in the field. All structural steel, a total of 3,262 tons, was furnished and installed by the Union Steel Co. of Los Angeles.

First the trusses were erected complete, and then they were riveted, starting from one end and working toward the other. After the two longitudinal trusses were completely riveted except for the bottom-chord connections, erection of the cantilever trusses began, again proceeding from one end of the hangar toward the opposite end. The transverse (cantilevered) roof trusses were connected across the main (longitudinal) trusses, to increase stability and provide sway bracing. Each transverse truss was located at the panel points of the main trusses. At each pair of columns at the ends of the main trusses, the portal, or basic sway bracing was installed, designed to take the total wind load on the building. The arches are 100 ft across, with steel column supports.

Each cantilever truss, as received at the site, weighed 35 tons. Two 20-ton cranes were used to lift one such truss into place, hoisting it 66 ft into the air. Detailing of both the columns and trusses followed standard practice for bridge construction.

An item of great concern during construction was the degree of sag in the huge cantilevered trusses, which extend 93 ft out from their supports in both directions. Sag was anticipated, and measures were taken during the placing of the trusses and riveting of the arches to slant the trusses slightly upward.

As soon as the roof section was complete, installation of the 66-ft-high doors began, two mobile cranes being used to put each leaf in place. Construction personnel held their breath for there was the chance that enough sag had not been provided for, and that the huge preassembled doors might not fit. Knute Hannston, Project Engineer for the job said, "As it happened, the doors fit like a glove."

The door panels line both sides of the hangar, and weigh between 18 and 22 tons each. This variation in weight is due to the fact that some of the panels have movable closure panels and removable fuselage inserts to provide for the tail sections of the different types of planes to be repaired in the hangar. These movable door panels allow the tail of a plane to extend out of the hangar during maintenance and repair operations, thereby providing maximum utilization of hangar space. Each opening in the doors is about 15 ft high by 7½ ft across. All openings are the same size, but are fitted with changeable foam rubber insets of proper size to fit the tail sections of the planes to be accommodated. This provision is important for heat retention.

The doors, which occupy the full length of the hangar on two sides, are of the rolling type, running on railroad tracks cast in the floor and supported on guide rails in the top of the hangar. There are 18 door panels, or leaves, on each side of the hangar, nine on each side of the center opening. When the doors open, the leaves roll back into a pocket along the side wall. The leaves are 30 or 35 ft wide and 66 ft (or 6½ stories) high. Each door is electrically operated by an individual motor and controlled by push buttons located at the ends of the hangar.

The hangar has a built-up roof of tar and gravel with copper-flashing expansion joints. The Lydick Roofing Co. was the subcontractor for all roofing materials, ventilators, and corrugated asbestos siding used on the outside, and hardboard wainscot used on interior surfaces.

Two traveling cranes have been installed in the ceiling of the hangar to speed maintenance and repair operations on aircraft. The cranes run lengthwise of the hangar, one on each side of the center support columns, and will be capable of lifting entire aircraft engines and moving them from one end of the hangar to the other. Hook load of the cranes is 10,000 lb.

Although the climate at this site is enviable in comparison with that at other places where such hangars are being constructed, temperatures range from 20 deg F in the winter to 115 deg F in the summer, and heating facilities are important. The hangar has three 309-hp boilers for winter use, and one 30-hp boiler for use during the summer. The boilers, which are in a lean-to on the outside of one end of the hangar, are gas fired with oil standby. They service heaters installed on the roofs of each of the shops, whence warm air is forced down into the hangar.

A special feature for the interior lights was incorporated into the design. To simplify maintenance and routine lamp changes, the lights were designed so that they can be lowered from the ceiling to floor level. Each light has an individual wire cord fastened to the side of the hangar within reach of maintenance personnel. With the unwinding of the cord, the lighting fixture can be lowered, the lamp changed or other maintenance performed, and the light then pulled back up into place. In a hangar 6½ stories high, this is an important safety as well as time-saving feature. The Action Electric Co. of San Francisco furnished and installed all interior and exterior electrical work, with the exception of the powerful floodlights on the roof, which were supplied by the Slater Electric Co. of Folsom, Calif. There are 96 of these floodlights, 48 on each side, and each has a rating of 1,500 watts, providing a near daylight effect.

In the states of California, Arizona, Utah, and Nevada, the construction of these hangars, as well as many other Air Force facilities, is monitored by the Air Force Installations Representative Office, South Pacific Region, with Col. Edwin M. Eads the officer-in-charge. Corps of Engineers construction agency responsibilities are handled by the South Pacific Division, with Col. William F. Cassidy, Engineer.

Structures formed by membranes on coactive groin ribs

PAUL C. CHELAZZI, M. ASCE, Engineer-Architect, New York, N.Y.

Structures supporting a gravity load formed by balanced arch and suspension systems may embody the high mechanical economy of axially stressed component systems while eliminating their common defect of exerting thrusts at supports. This concept is expressed in a three-dimensional form in the roof structure of Fig. 1, as the thrusts exerted by the membrane on each side of a rib stabilize the rib and cause no bending but axial stressing only. In fact, as shown in Fig. 1, these membrane thrusts, dZ, produce vertical components, dP, and horizontal ones, dH, of which dT is the resultant. Should the axis of the rib coincide with the line of action of dR, the resultant of dP and dT, the rib would be axially stressed throughout, under uniform loading conditions.

The notation in Fig. 3(*a*) is for the linear rib axis of Fig. 3(*b*). For this rib axis, originating at center O and having a similar inclination angle, β, as the resultant dR, the maximum axial load R_O is given by the equation,

$$R_O = \int_O^{L_2} \frac{1}{2} wc \sin^2 \alpha \cos \alpha \times \left(1 + \frac{16}{c^2 \sin^2 \alpha}\right)^{1/2} x \, dx \quad . \quad . \quad . (1)$$

Should the shape of the rib axis follow a curve expressed by a continuous function with origin at center O, the load R will be axial if the sag-span ratio of the membrane ring elements intersecting at the rib is equal to the x-derivative of said curve function at that point multiplied by $^1/_4 \sin \alpha$. And the magnitude of the axial load R_O will be,

$$R_O = \int_O^{L_2} 4w \sin \alpha \cos \alpha \times \left(x^3 + \frac{1{,}024x^4}{\sin^4 \alpha}\right)^{1/2} x \, dx \quad . \quad . \quad . (2)$$

As this equation is an elliptic integral, its solution involves considerable elaboration in a binomial series, which may prove impractical for actual design. However, satisfactory results have been obtained in applying the simpler method

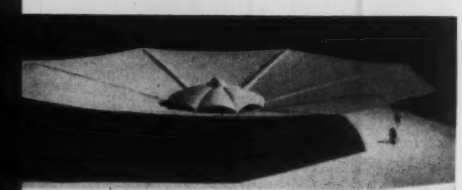
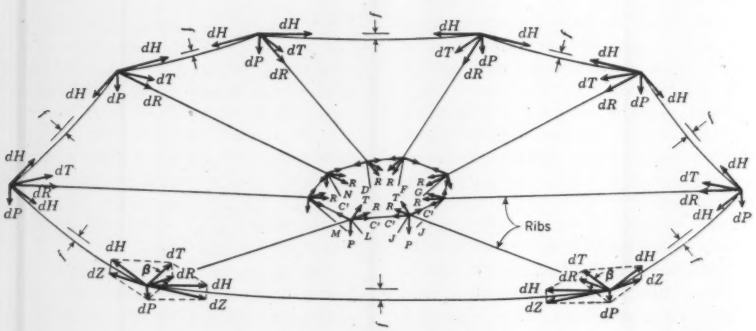


FIG. 1. Structure formed by balanced arch and suspension systems embodies mechanical economy of axially stressed component systems without their common defect of exerting lateral thrusts at supports. See model above and thrust diagram at right.



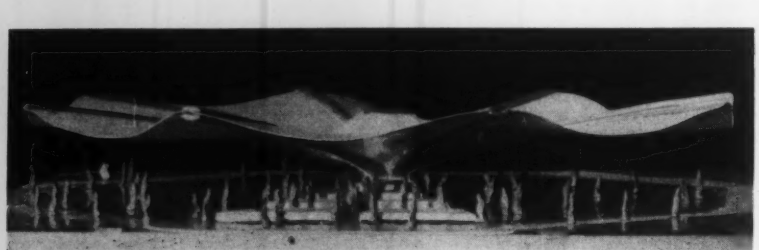


FIG. 2. Concrete ribs in grouted steel-mesh membrane structure (left) are axially stressed throughout, but will be steel reinforced to provide lateral stiffness and to resist bending due to unsymmetrical and upward wind loading. Reinforcing will be determined from results of wind-tunnel tests.

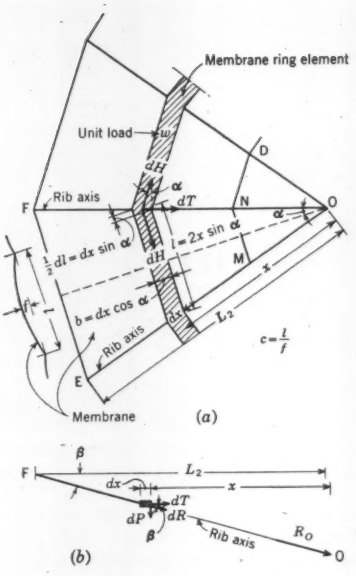


FIG. 3. Notation and loading for linear rib axis originating at center O are shown for Eqs. 1 and 2.

of finite differences for the investigation of the structure shown in Fig. 2, which is designed in the form of cement-grouted steel-mesh shells of the type developed by Prof. Pier Luigi Nervi of Rome, Italy, and described in his article in CIVIL ENGINEERING for February 1953. Plans for building an exhibition stand based on this design, with a rib span of 40 ft, may soon materialize.

Originally designed in stainless steel, with a span of 81 ft between ribs, the structure shown in Fig. 1 may also be constructed with a glass or plastic dome over the central mezzanine floor area. Possibilities in aluminum, acrylic plastic, and fiberglas-resin as covering and stiffening materials for membranes supported by cable wire are being investigated. Applications to irregular floor plans have also been tentatively designed. It should be noted that under conditions of symmetrical upward wind loading, the membrane will respond mechanically as a system of thin vaults, which can be so designed as to offer adequate resistance. For large rib spans, stabilizing tiedowns can be provided at the outer ends of the ribs.

Although the concrete ribs in the grouted steel-mesh membrane structure of Fig. 3 are axially stressed throughout, steel reinforcement will be provided to stiffen them laterally and to resist bending due to an unsymmetrical and upward wind loading. Reinforcement for the ribs will be based on the results of wind tunnel tests.

THE READERS WRITE

Recognition sought for maintenance engineers

TO THE EDITOR: In recent years increasing attention has been given to the importance of maintenance of real property and fixed equipment. This has resulted in many management staffs developing planned programs of maintenance and replacement based on sound engineering experience and judgment rather than making day-to-day repairs due to necessity. In attacking this problem, it has become increasingly evident that the maintenance of real and fixed property, as well as the replacement of buildings and equipment, needs the attention of trained engineers. The annual maintenance cost in the United States today is big business, representing expenditures of billions of dollars.

To insure safe operating conditions, maximum use and minimum maintenance cost, the maintenance engineer must be familiar with the various types of construction, use of materials, functional requirements of the particular structure or utility, as well as with current improvements in building materials and construction techniques. This is a field for which the civil engineer is particularly well suited. His wide range of training and experience in the design, construction and operation of structures, utilities, highways, bridges, railroads, etc., provides him with the know-how to solve the many intricate and sometimes baffling problems encountered in the maintenance and safe operation of such structures.

To weigh the various factors, and determine the most efficient and economical manner in which maintenance should be accomplished, takes this vitally important operation out of the hands of general mechanics and places it definitely in the hands of engineers.

This view is substantiated by the exacting standards for this type of work demanded by industry as well as the ever-increasing importance placed on this activity in government. It is also becoming evident to smaller organizations, such as privately operated hospitals, that engaging the services of professional engineers for maintenance work pays dividends.

In industry, particularly, it is important that plant and equipment operate without shutdowns for excessive repairs. Uninterrupted operation, due to good maintenance, increases productivity and reduces manufacturing costs.

In government, lowered maintenance costs pay dividends in the extended life of buildings and equipment, as well as in a reduction in operating costs, which are reflected in lower costs to the taxpayer.

Further, with the continually rising cost of structures and utilities, it becomes more essential that the useful life of such buildings and equipment be extended as much as possible. This requires carefully planned programs of maintenance and replacement, with full utilization of preventive maintenance, anticipated obsolescence, and long-range plans for orderly replacement.

This particular type of engineering work should receive proper recognition as a specialized field, and engineers engaged in it should be accorded a definite classification. This is of utmost importance today, because of the shortage of engineers, in order to attract well qualified and experienced men to this field of engineering. To increase interest in this field of engineering, the development of Classification Standards in the government service is most important. Another means of aiding this specialized engineering service would be through recognition of this group of engineers by engineering societies concerned with the broad aspects of engineering.

GLENN R. STEVENS, M. ASCE
Director, Eng. Service, Dept. of Medicine and Surgery, Veterans Admin.
Washington, D.C.

Influence lines for circular and parabolic arches

TO THE EDITOR: It has come to my attention that C. R. Young and M. W. Huggins, in Research Bulletin No. 148 (1935) of the School of Research of the University of Toronto, have presented influence values for circular and parabolic arches like those included in Table I of my article, "Direct Design of Two-Hinged Arches of Constant Section," in the January issue.

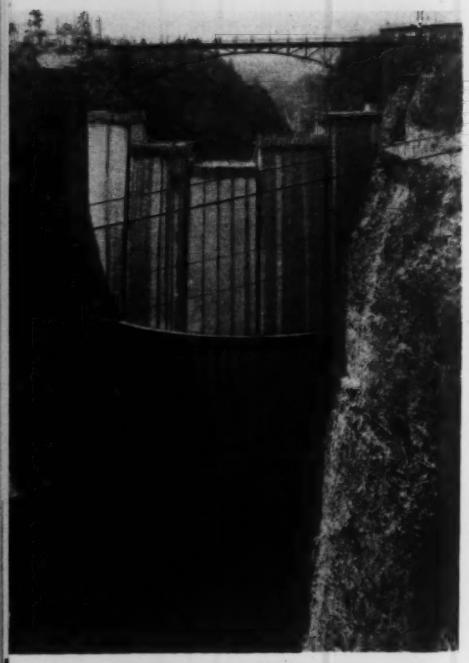
This article is the first of two which attempt to synthesize design factors for two-hinged and hingeless arches. Had I been aware of the existence of these useful tables by Young and Huggins for two-hinged arches, I would certainly have included a reference to them in my article.

Influence values were also determined for semi-elliptical curves for the two-hinged arches, but were not included in Table I of my article since this table applies primarily to steel structures. They will be included in my second article, "Direct Design of Hingeless Arches of Constant Section," to appear in a forthcoming issue of CIVIL ENGINEERING.

JAMES MICHALOS, M.ASCE
Prof. of Structural Eng. and Chairman, Dept. of Civil Eng. New York University
New York, N.Y.

SOCIETY NEWS

Knoxville Convention Will Feature . . .



The Society's Summer Convention—to be held in Knoxville, Tenn., June 4–8, with the Tennessee Valley Section as host—will feature more than 100 technical papers covering eleven major fields of the profession. As to be expected of a meeting in the heart of the TVA country, power projects, both at home and abroad, will receive plenty of attention. The detailed program was printed in the April issue.

Design and construction of dams and other power facilities will be the theme of an unusual group of papers by engineers from France, Italy, Japan, and Portugal. Of special interest in this connection will be the studies of spectacular European developments in the arch-dam field. Andre Coyne, Hon. M. ASCE, famous French engineer, will lead off one of the sessions with a paper on "The Philosophy of Arch Dams." Portuguese experience with overflow arch dams, in which the whole structure is the spillway, will be reported. Modern Italian experience with single- and double-curvature arch dams will also be described. Some Italian engineers are cutting construction costs by locating these dams in extremely high, narrow gorges.

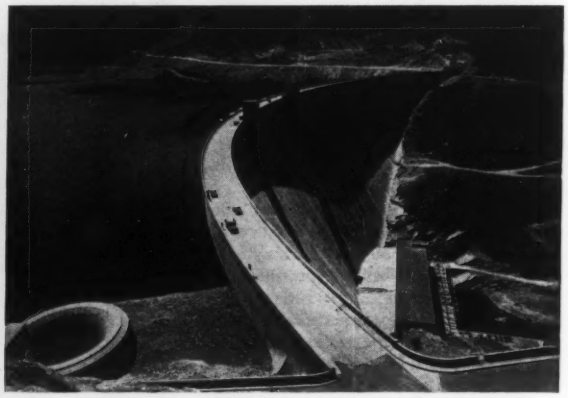
An American paper will give a brief history of the development of the trial load method for stress analysis of arch dams and the application of these procedures to the design of Hungry Horse Dam—a Bureau of Reclamation gravity-arch project, completed in 1952. Of local interest in this connection will be TVA's Fontana Dam and the Aluminum Company of America's Cheoah, Calderwood, and Chilhowee dams, objective of a Saturday inspection trip.

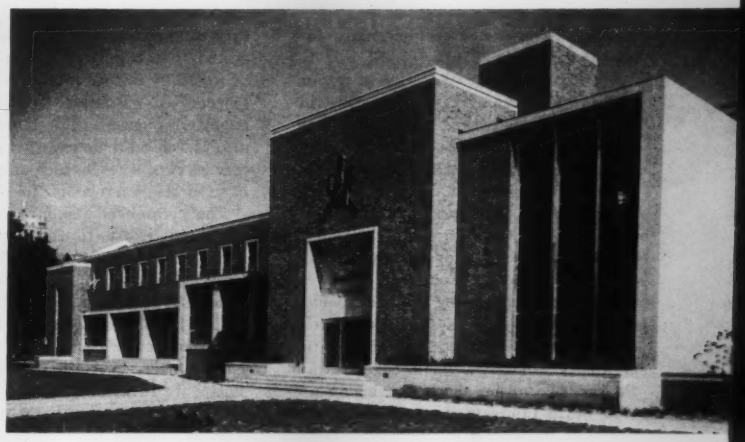
Dam Symposium to Be Published

Much credit is due the Power Division, which has been working on the arch-dam symposium for over two years. The papers scheduled for the five-session program are being published in the Power Division Journal and will be available at the Convention in reprint form. Persons not attending the Convention may order the reprints by use of the regular CIVIL ENGINEERING coupon.

The Structural Division announces an addition to its elaborate program outlined in the March and April issues. Featured speaker at the Structural Division Dinner—to be held in the Andrew Johnson

Santa Giustina Dam in Italy (upper view) is 500-ft-high single-curvature arch dam located in extremely narrow gorge. View shows upstream face when construction was practically completed. Provisional joints are already closed and sealed in the lower part of the dam. Steel forms for the pours are visible at the top. Bouca Dam in Portugal (lower left photo) is overflow arch structure. It is 200 ft high and has flood discharge of 45,910 cfs. Its unusual feature is that the whole dam is the spillway. Hungry Horse Dam in Montana (lower right) is 515-ft-high gravity-arch structure originated by Bureau of Reclamation. Glory-hole spillway may be seen in left foreground. These are some of many interesting structures to be discussed in Power Division's arch-dam symposium.





Objective of one of Knoxville Convention field trips will be TVA's Hydraulic Laboratory at Norris, Tenn., where engineers are constructing giant model of world's highest single-lift navigation lock (left-hand photo), proposed for installation at Wilson Dam, Alabama, to augment the present obsolete locks. Here Brig. Gen. Herbert D. Vogel, M. ASCE, chairman of the TVA (left); Rex Elder, M. ASCE, head of the laboratory (center); and Clarence E. Blee, M. ASCE, chief engineer of the TVA, observe a model of the culverts and ports that will be used in the proposed lock. Shown at right is Carolyn P. Brown Memorial University Center at University of Tennessee, which will be headquarters for Knoxville Convention. (Photo courtesy of Knoxville Chamber of Commerce.)

Hotel, Thursday evening, June 7—will be Maj. Gen. Lee B. Washbourne, Assistant Chief of Staff, Installations, U.S. Air Force Defense Program. His subject will be "The Engineer in Our Military Defense Program."

Arthur E. Morgan, Hon. M. ASCE, first TVA chairman and now president of Community Services, Yellow Springs, Ohio, has been announced as the principal speaker at the Hydraulics Division Dinner on June 7. The present chairman of the TVA, Brig. Gen. Herbert D. Vogel, will also be one of the many interesting TVA personnel represented on the Convention program.

Nathan W. Dougherty, dean of the College of Engineering at the University of Tennessee, will speak on the timely subject, "Educating a Professional Engineer," at the Wednesday Convention Luncheon. At the Membership Luncheon on Thursday ASCE President Enoch R. Needles will give his presidential address, which will be entitled, "Where Are We Going?"

Entertainment to Feature Local Color

The Entertainment Committee, under the chairmanship of Nathan E. Way, is taking full advantage of the folklore and picturesque customs of the region in planning the social program. Perhaps the high point of the program will be the dinner, entertainment, and Smoky Mountain Square Dance set for Wednesday evening, June 6, at the University Center. A leading East Tennessee Square Dance orchestra will provide the music, and one of the most famous square dance callers in the region will exercise his calling. Lack of know-how need not keep you from enjoying the dancing, as a group of costumed "hillbillies" will demonstrate just how it should be done. However, the committee warns that low heels and comfortable clothing are a "must" for this event. Trips into the Great Smoky mountains and to the Gatlinburg craft shops will give the ladies additional glimpses of local color.

Variety of Inspection Trips Offered

Friday, June 8, has been set aside for inspection trips to some of the many interesting projects that make the Knoxville area an engineer's paradise. On the agenda are the Kingston Steam Plant, largest in the world (with a capacity of 1,600,000 kw) and now in full operation; the Oak Ridge National Laboratory, including the graphite and "swimming pool" reactors and the high-voltage laboratory; the Museum of Atomic Energy; Norris Dam; and the TVA Hydraulic Laboratory. At the laboratory tests are being made on models of the new Wilson Dam lock, which will have the highest lift in the world. For those especially interested in arch dams there will be the Saturday trip to Fontana, Cheoah, Calderwood, and Chilhowee dams.

Don Mattern Convention Chairman

Among the big names in Convention planning are Don H. Mattern, who is general chairman; Ernest M. Titus, secretary-treasurer; and George P. Palo, president of the host Section.

AGC-ASCE Joint Cooperative Committee Meets

Continued and, if possible, increased cooperation between the Associated General Contractors and ASCE Student Chapters was agreed upon at a meeting of the AGC-ASCE Joint Cooperative Committee, held in New York during the AGC's recent annual convention. The joint group also agreed to recommend that civil engineering curricula be broadened in scope by the development of undergraduate elective courses more closely related to construction engineering.

In a review of the AGC's scholarship program for worthy engineering students, it was agreed to recommend periodic review of programs and to encourage making the awards smaller in order to afford aid to the maximum number of interested students. It was the consensus of the group that it is advantageous to have each student contribute to some extent towards his own education. The group also decided to recommend intensification of the summer employment program of con-

tractors and awarding agencies for student engineers to further careers in construction engineering.

A discussion of the allocation of responsibility for "stake out" work on construction projects indicated that many contractors do not have adequate engineering staff to complete all the necessary provisions of the normal contract. It was recommended that present "stake out" provisions in all documents relating to construction be improved and clarified; that contractual agreements between owners and consulting engineers more clearly define the consultant's jurisdiction and responsibilities; and that duplication of survey work by owners' engineers and the contractors be eliminated where possible in the interests of construction economy and conserving available engineering manpower.

The joint committee also discussed methods of securing maximum use of existing engineering manpower and suggested that engineering man-hours could be saved by not assigning professional engineers an excessive amount of non-engineering detail. Special emphasis was also placed on technical two-year training courses in colleges for increasing the supply of subprofessional people for office work.

The committee also took cognizance of continuing efforts to unionize engineers in the construction industry and reaffirmed its opposition to their inclusion in heterogeneous trade unions.

Charles B. Molineaux, of the Arthur A. Johnson Corporation, New York, is co-chairman of the Joint Cooperative Committee for ASCE, and A. S. Horner, of the A. S. Horner Construction Company, Denver, is co-chairman for AGC. Don Reynolds is co-secretary for ASCE, and A. N. Carter for AGC.

Freeman Fellowship To Be Given in 1957

The Freeman Fellowship Committee announces that no award will be made in the 1956 competition, which was conducted by the American Society of Mechanical Engineers. Applications for the 1957 award will now be received for consideration by the ASCE Committee on the Freeman Fund.

By agreement between the two societies, the fellowship is awarded by ASCE in odd-numbered and ASME in even-numbered years. It is open to members of both societies in any year, regardless of which society is sponsoring the award program that year. This procedure has made it possible to increase the stipend.

E. S. Library to Have Technical Book Exhibit

Some 250 French scientific and technical books will be on exhibition in the Engineering Societies Library, 29 West 39th Street, New York City, during the month of June. Engineers, educators, scientists, and researchers will be able to examine at their leisure an unusual selection of books made available by the Cultural Division of the French Embassy, through the cooperation of leading publishing firms in France. One of the purposes of the exhibit is to keep American engineers and scientists informed of the advances made by their French colleagues. The books will represent all the engineering branches; industrial physics; and mathematics, physics, and the earth sciences.

The exhibit will be in the Reading Room of the Library, which will be open from 10 a.m. to 5 p.m., Mondays through Saturdays.

Index to Constitution

For convenience in referring to the ASCE Constitution, Bylaws, and Rules of Policy and Procedure, the Society has prepared a detailed eleven-page Index. Members wishing to have a copy may make a postcard request to Society Headquarters. The full text of the Constitution, Bylaws, and Rules of Policy and Procedure appears in the Official Register, which was mailed to every member in March.

ECPD Issues Annual Report

Availability of the Twenty-Third Annual Report of Engineers' Council for Professional Development is announced by that organization. This new edition of what has become a classic in the field includes among other things a list of accredited curricula. Separate lists of accreditation data—"Curricula Leading to First Degrees in Engineering" and "Technical Institute Programs"—are also available. They sell for 25 cents each, and the Annual Report is $1.00 a copy. Inquiries should be addressed to ECPD, 29 West 39th Street, New York 18, N. Y.

Increased Use of E. S. Library Noted

More persons visited the Engineering Societies Library in the recently concluded fiscal year than in the preceding year, and more persons were also served by mail, telephone, and telegraph in this period. There was a 63 percent increase in the number of words translated, and a 33 percent increase in orders for bibliographies. More books were borrowed. More photoprints, microfilms, and searches were also made for users of the Library. The number of visitors to the Library was 18,696, and the number of non-visitors served was 21,740. The Library staff prepared reviews of 605 books, an 8 percent increase over the preceding year. The staff is equipped to translate from and into a dozen languages, and last year their translated output was 425,156 words.

Recent increased use of the Library continues a trend that is shown by comparing the Library's income from paid services five years ago and now. In the 1949–1950 fiscal year this income came to $24,289, and in the 1954–1955 period it was $41,127. The figures are comparable since service rates have not changed during the period.

These are some of the facts brought out in the Forty-Second Annual Report of the director of the Library. Ralph H. Phelps is director at 29 West 39th Street.

Movie of Texas Tower Available

Gordon F. A. Fletcher's article, "Heavy Construction Goes to Sea—First Atlantic Radar Platform Installed on Georges Bank," in the January issue, aroused much favorable comment. An excellent colored moving picture with narration showing construction progress to completion has been produced by the author's company (Raymond Concrete Pile), which is generously making it available for showing at meetings of ASCE Local Sections and Student Chapters. When practicable a Raymond representative will be present at showings.

Requests should be directed to C. A. Hegyes, Graphic Arts Department, Raymond Concrete Pile Company, 140 Cedar Street, New York 6, N.Y. Give at least two alternate dates.

Proceedings of ASCE—A Statement of Policy

For a century the PROCEEDINGS of the Society have been held in esteem by civil engineers all over the world. To defend that prestige and, if possible, to advance it should be the constant concern of every Society officer, committeeman, and member. Under a far-sighted policy of adaptation to modern demands, recent years have seen several changes and improvements in response to that concern. More papers have been published, Division journals have been created, and automatic distribution has been extended to registrants in two Technical Divisions, instead of one.

In applauding these long strides, one cautionary note is in order. The quality of our PROCEEDINGS papers is said to be declining due to a new and growing dependence on meeting programs as the most important source of papers. This new trend must not perpetuate an impression that papers prepared for oral presentation at a meeting are the most important source of technical papers. The channeling of technical papers for publication must not be delegated to Division program committees, whose basic objectives and aims may differ from those of a publisher. Much valuable technical material is released to the profession through oral presentation at meetings, but the time allotted is necessarily too brief to present basic theories and interpretations for calm study and detailed application to practice. The ideal paper is one that is prepared first for publication and later abstracted to suit the time limitations and other requirements of an oral presentation. A meeting program necessarily will generate many important papers of local importance—and of pointed importance—to the success of the meeting itself, but these should not be accepted, *per se*, as material for widespread discussion in the technical publications of the Society.

The Society's Publications Committee believes that the technical *programs* function and the technical *publications* function are two equally important arms of Society activity. One should never be held subservient to the aims and purposes of the other. For greatest effectiveness they should be independent entities within the Society, mutually cooperative, but each one free to advance the Society's aims and objectives in its own particular way.

To this end, the Society's Publications Committee has proposed, and the Board of Direction has adopted, the following four points of basic policy:

1. The authority of the Division program committees and the Division publications committees should be kept distinctly separate, under the general surveillance of the ASCE Division Activities Committee; and the members of one should not be selected for service on the other at the same time.

2. Division program committees should abstain from encouraging meeting speakers to expect that their speeches will be published in PROCEEDINGS, though speakers with manuscripts suitably prepared for publication may properly be advised to submit them to Society Headquarters for review by the appropriate Division publication committee.

3. Manuscripts written informally, for oral presentation, will be rejected before entering the standard Division reviewing procedures.

4. Division publications committees should encourage authors to submit to Society Headquarters papers prepared for publication primarily, and to refer such papers for the consideration of Division program committees as the basis for meeting program presentation.

Washington Award Goes to Robert E. Wilson

Robert E. Wilson, chairman of the board of the Standard Oil Company (Indiana), is this year's recipient of the Washington Award. Presentation of the award to him was made at a dinner held in Chicago on May 1 under sponsorship of the Western Society of Engineers. Founded in 1916 by the late John Watson Alvord, the award is administered by the Western Society of Engineers on the recommendation of a commission representing the four Founder Societies and the Western Society of Engineers. It is described as an "honor conferred upon an engineer by fellow engineers for accomplishments which preeminently promote the happiness, comfort, and well-being of humanity."

The citation accompanying Mr. Wilson's award hails him for "unusual dedication of leadership through science and engineering to the advancement of research, industry, education and public affairs." As a businessman Mr. Wilson is widely known as a self-trained economist on oil-industry affairs as well as for his aggressive management of Standard Oil. In 1940 he headed the natural gas and petroleum section of the government's National Defense Advisory Commission, and later was a leading member of the National Petroleum Council. He has been chairman of the board of Standard Oil since 1945.

Annual Business Meeting To Be Held in Pittsburgh

Except as the Board states otherwise, the Society's Annual Business Meeting must be held in New York City, and it has customarily been a feature of the Annual Convention. With the 1956 Annual Convention slated for Pittsburgh, the Board has taken necessary action to permit holding the meeting in that city in October during the Pittsburgh Convention. The date of the Annual Business Meeting will be Wednesday morning, October 17.

Coming Events

Intermountain—Dinner meetings on the third Friday of the month, except during June, July, and August.

Metropolitan—Last meeting of the season in the Engineering Societies Building, May 16, at 7 p.m.

Mid-Missouri—Dinner meeting at Fort Leonard Wood, May 11.

Mohawk-Hudson—Joint meeting with the Connecticut Section on May 22. Program includes noon luncheon; inspection of natural cement plant and West Point facilities; and dinner meeting at Hotel Thayer, West Point.

Nashville—Joint meeting with Vanderbilt University Student Chapter, May 17, at 6:30 p.m. Graham Willoughby, ASCE Director for District 10, will be the principal speaker.

Philadelphia—Annual outing, followed by annual meeting, installation of officers, and dinner-dance at the Torresdale-Frankford Country Club, May 11. Luncheon at 12:30 (Dutch Treat) and dinner at 7 p.m.

Sacramento—Weekly luncheon meetings at the Elks Temple every Tuesday at 12 noon.

Syracuse—All-day field trip to the St. Lawrence Seaway Project on May 19. Cost of the trip will be $6.00. Reservations must be sent at once to F. R. Sandker, 416 Thurber St., Syracuse 5, N. Y.

Wisconsin—Ladies Night on May 22. Tour of Capitol Court Shopping Center, Milwaukee, at 5:30, and dinner at Tripoli Country Club at 7:30 p.m.

NOTES FROM THE LOCAL SECTIONS

(Copy for these columns must be received by the tenth of the month preceding date of publication.)

The **Arizona Section's** new slate is W. L. Heckler, Tucson, president; L. O. Gardner and C. H. Whalin, Phoenix, vice-presidents; R. M. Cushing, Tempe, secretary-treasurer; and J. B. McDonald, Phoenix, Junior Member assistant to the secretary-treasurer. The Section's recently formed **Phoenix Branch** reports a good first meeting, devoted to discussion of the Ford Motor Company's new proving track at Yucca, Ariz. Procedures used in laying out the five-mile oval track (designed for speeds of up to 140 mph) were explained by Carl Barth, engineer with Johannessen and Girand, and Warren Hunter, chief engineer of the Fisher Contracting Co.

Difficulties arising in obtaining the air rights for the Prudential Life Insurance Building in Chicago—the city's first new skyscraper in twenty years—were outlined at a recent meeting of the **Central Illinois Section** by C. H. Mottier, vice-president and chief engineer of the Illinois Central Railroad. Featured speaker at the March meeting was Executive Secretary W. H. Wisely, former member of the Section, who summarized the workings of the Society.

Some of the problems involved in concrete usage were aired at a recent Concrete Conference co-sponsored by the **Cleveland Section,** the Portland Cement Association, the American Concrete Institute, and Case Institute of Technology. Discussion covered failure of the reinforced concrete rigid frames in the government warehouse at Shelby, Ohio (February issue, page 45); recent changes in the ACI Building Code; and prestressed concrete products ("Tee," "Double Tee" and channel-shaped roof deck, with spans up to 30 ft, prestressed beams and columns, and prestressed piles) being manufactured by the firm of Lakeland Engineering Associates, Inc. The experts were Raymond C. Reese, consulting engineer of Toledo, Ohio; Malcolm S. Douglas, city engineer of East Cleveland; and H. H. Edwards, president of Lakeland Engineering Associates, Inc., Lakeland, Fla.

Scheduled ASCE Conventions

KNOXVILLE CONVENTION
Knoxville, Tenn.
University of Tennessee
June 4–8, 1956

PITTSBURGH CONVENTION
Pittsburgh, Pa.
William Penn Hotel
October 15–19, 1956

JACKSON CONVENTION
Jackson, Miss.
Hotel Heidelberg
February 18–22, 1957

The pros and cons of the Fallon Bill were explained at the **Connecticut Section's** March 16 meeting, which was devoted to highways. Featured speaker was Newman E. Argraves, state highway commissioner and member of the Section. U.S. Senator Prescott Bush sent an eight-page telegram on the National Highway Program, which was read and discussed.

Members of the **Duluth Section** also devoted their March meeting to the proposed National Highway Program. J. E. P. Darrell and Clinton Burns, of the Minnesota Department of Highways, discussed pending legislation in relation to Minnesota's highway needs.

At the **Georgia Section's** meeting on highways it was D. L. Chaney, manager of the Washington, D.C., office of the Portland Cement Association, who described the needs and provisions of the current interstate program. Mr. Chaney placed emphasis on the program's provision for credit for the states that have made attempts to keep their highway construction in line with present-day traffic needs.

The desperate need for an expanded highway program and methods of financing it also occupied the attention of **Illinois Section** members at a recent meeting. Speakers were Robert Harrison, district engineer for the Bureau of Public Roads, and M. C. Sielski, head of the Traffic Engineering and Safety Department of the Chicago Motor Club.

ASCE President Enoch R. Needles and Director G. P. Willoughby (seated) were among 125 members and guests of Alabama Section at recent all-day meeting at Auburn, Ala. Shown standing are Ed Hardin, president of University of Alabama Student Chapter; Section President Raymond E. Strickland, and Hugh Kilgo, president of Alabama Polytechnic Institute Student Chapter, which was host to the Section and the University of Alabama Chapter.

Joan T. Earle, civil engineering student at University of Maryland and first woman engineer to address Maryland Section, speaks at March meeting on "Women in Engineering." Alton C. Hlavin, civil engineering senior at Johns Hopkins University, spoke on the St. Lawrence Seaway. During the meeting which was conducted entirely by students of the two universities, the Johns Hopkins University Student Chapter presented a scroll to Prof. J. Trueman Thompson, who is retiring from the chairmanship of the civil engineering department there.

New **Indiana Section** officers are Joseph H. Byrd, Whiting, president; Frank Stubbs, West Lafayette, vice-president; Robert J. Cooney, Speedway, secretary-treasurer; and Joseph Hnot, Jr., Highland, assistant secretary. Mr. Hnot is also president of the Section's **Northwest Branch.**

Congratulations are in order for the **Intermountain Section,** which will celebrate its fortieth anniversary in June. To serve better its 241 members scattered all over Utah and parts of Nevada, the Section is planning to start a monthly newsletter. A film entitled "Making and Shaping of Steel" was shown at the March meeting by Bob Adams, senior sales representative of the Columbia-Geneva Steel Co., U.S. Steel Corporation.

ASCE MEMBERSHIP AS OF APRIL 9, 1956

Members	9,145
Associate Members	11,818
Junior Members	17,708
Affiliates	72
Honorary Members	41
Total	38,784
(April 8, 1955	38,219)

Two cents a day for the average passenger car operator who drives 10,000 miles a year would pay for the federal highway program under the Fallon Bill. This was the aspect of the highway program emphasized at the **Kansas Section's** meeting on the subject. The speakers were Walter Johnson, state highway engineer, and M. W. Watson, Topeka contractor. At another recent meeting R. L. Peyton and R. C. Meyer, engineer of research and electronics engineer for the Kansas Highway Commission, discussed the work of the Research Department. Mr. Meyer also demonstrated a useful device—a "profilometer"—he has developed for automatically plotting road profiles.

This year **Metropolitan Section** honors go to Jacob Feld, distinguished consultant, who has been named "Metropolitan Civil Engineer of the Year" in the fourth annual award of this distinction. Dr. Feld is specifically honored for his work on New York's mammoth Coliseum Project, which is being completed this spring (page 79). His citation hails him as one of the Section's "foremost consulting engineers, always active in research to find new and improved methods and materials," and lauds his "inquiring mind." For the first time the Section is also naming a Junior Engineer of the Year—to be chosen on the basis of published work, since Junior Member experience is necessarily limited. This year's recipient is J. D. Welch, who is honored for a paper on "Rock Weathering Classification of Excavation Slopes," which was published in July 1955 as Proceedings Paper 754.

The **Mid-Missouri Section** enters the newsletter field with Vol. 1, No. 1 of a highly creditable mimeographed monthly called the "Mid-Missouri Section News." Two enterprising Junior Members—Richard Johnson, of Kirksville, and Frank M. Yeckl, of Rolla—are the editors.

The Mississippi River Commission's program to control the natural diversion of the Atchafalaya River was the subject of an informative talk heard at the March meeting of the **Mid-South Section's Jackson Branch.** Maj. Gen. J. R. Hardin, president of the Mississippi River Commission, was featured speaker. The new Little Rock-North Little Rock (Ark.) Superhighway was discussed at a meeting of the **Little Rock Branch** on March 21. The speaker—Harold A. Blauvelt, of Brown and Blauvelt, New York consultants on the project—told the group that completion of the five-mile $28,000,000 project will take about four years "at normal construction pace." The rehabilitation work of the U.S. Armed Forces in Korea was described at a recent meeting of the **Vicksburg Branch** by Lt. Col. T. G. Harton, assistant Vicksburg district engineer.

Both sides of the issue of unionism versus professionalism were well brought out at a recent meeting of the **Mohawk-Hudson Section** held at Union College in Schenectady. Junior Members were in charge of the program, which featured talks by Russell M. Stephens, president of the American Federation of Technical

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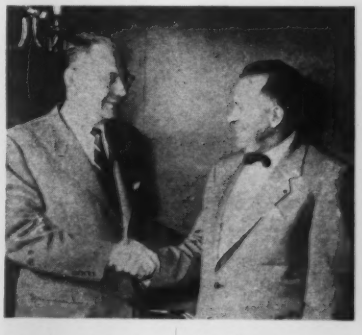
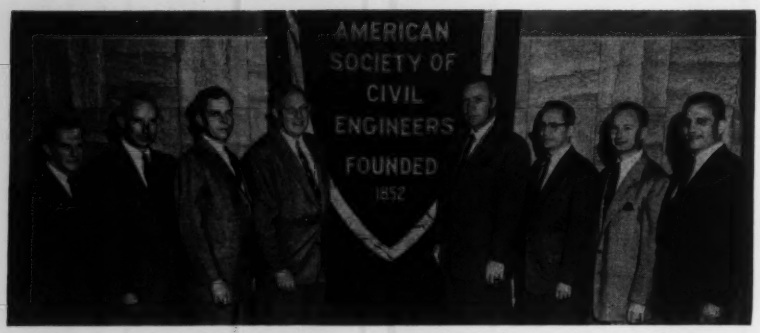
Edmund Wilkes, Jr. (left) and John A. Strang (right) display their Life Membership Certificates awarded at recent meeting of Kansas City Section. They are shown with Ellsworth L. Filby, who introduced them. Presentations were made by Section President L. G. Feil. Featured speaker at the meeting was R. G. Paulette, of Industrial Service Division of Municipal Service Company of Kansas City. In talk on stream pollution problems, Mr. Paulette pointed out that treatment and control of industrial wastes can benefit industry by saving plant operation costs.



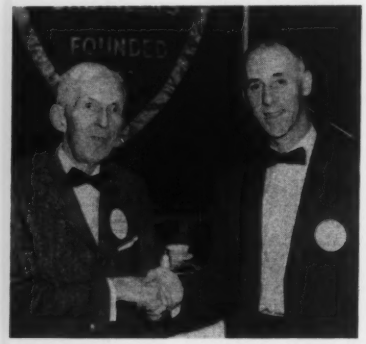
"Congratulations and good luck" is the sentiment of Glenn E. Hands (right) as he turns over the stewardship of the Kansas City Section to the new president, L. G. Feil. Mr. Feil is chief of the Engineering Division of the Kansas City District of the Corps of Engineers, with which he has been connected for 22 years.



Los Angeles Section officers, out in full force for March meeting of Los Angeles Section, are (in usual order) L. J. Alexander, past-president; Sterling S. Green, past-president; L. LeRoy Crandall, vice-president; Ernst Maag, vice-president; George E. Brandow, president; Jack E. McKee, secretary; Alfred E. Waters, treasurer; and Philip Abrams, Junior Member Forum representative. Technical program consisted of a symposium on the impact of modern freeways upon the community and the individual. Featured speakers were Dexter MacBride, senior right-of-way agent for the California Division of Highways, and Hugo Winter, assistant engineer of design for the Los Angeles Bureau of Engineering. Meeting was a joint session with the Section's Transportation Group.

Current officers of the Mexico Section are (left to right) Lorenzo Perez Castro, president; Earle S. Sloan, past president; and Miguel Montes de Oca, secretary-treasurer. Leopoldo Farias is vice-president.

Northeastern University Student Chapter honors Dr. Carl S. Ell (center), president of the university, with certificate of honorary membership. Shown with him are William P. Shine (left), Chapter president, and Angelo P. Toyias, Chapter secretary.



Edward C. Keane (right), newly elected president of Northeastern Section, receives congratulations from Frank B. Sanborn, the Section's first president (1921–1922) at annual meeting in which all living ex-presidents were honored.

Engineers, who presented the union viewpoint, and ASCE Assistant Secretary E. Lawrence Chandler, who outlined professional principles. Discussion from the floor indicated intense interest in the subject, with salaries and unification of engineers into one organization the big talking points.

David Donaldson has resigned as secretary-treasurer of the **Billings Branch** of the **Montana Section** to enter the U.S. Navy. Robert B. Dean has been appointed to fill out the remainder of his term. Mr. Dean's address is 2618 Broadwater Avenue, Billings, Mont.

Outstanding Student Chapter members in the Washington, D.C., area received $40 "scholarship awards" at the **National Capital Section's** meeting on March 13. They were Thomas H. Birmingham, of George Washington University, and Charles L. Crawford, of Howard University. In anticipation of annual conventions of the American Congress on Surveying and Mapping and the American Society of Photogrammetry, scheduled to be held in Washington the following week, the technical program was devoted to these subjects. Robert H. Randall assistant to the division chief, Resources and Civil Works Division, Bureau of the Budget, discussed some of the difficulties encountered in surveying and mapping, especially in the work of government agencies. Of much interest also was his discussion of some of the instruments used in modern cartography.

Earth moving and economic considerations involved in the various methods was the subject of an interesting talk given at the March meeting of the **Northwestern Section.** Featured speaker C. C. Morrill, of the Caterpillar Tractor Company, used films and slides to describe the equipment.

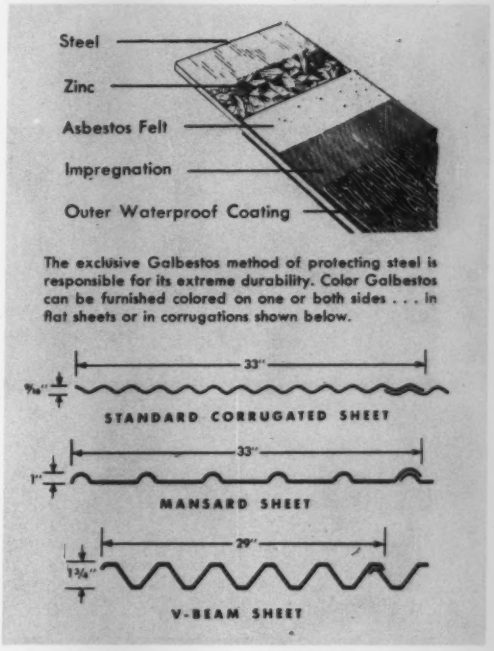
Lumber grading, with special reference to the results of the recent changes in grading designation in the Douglas Fir region, was the program topic at a recent meeting of the **Oregon Section.** T. K. May, technical director of the West Coast Lumbermen's Association, assisted by Inspection Bureau supervisors, demonstrated lumber grading on numerous samples. At the same session ASCE Vice-President Glenn Holcomb gave a report of Board actions at the Dallas Convention. Featured speaker at another recent section meeting was C. H. Ferguson, West Coast manager of the Prepakt Concrete Company, who explained the Prepakt method of construction.

Professional subjects held the stage at the **Philadelphia Section's** March meeting. In a talk entitled "The Future of the

Low cost, maintenance-free beauty for your roofs and sidewalls . . .

After decades of research and more than seven years of exhaustive tests held under the auspices of its multiple fellowship at the famed Mellon Institute of Industrial Research, H. H. Robertson Company is proud to announce Galbestos roofing and siding in four attractive new colors—red, green, buff, gray. Galbestos in black or maroon has long been the standard of perfection among protected metal roofing and siding materials for its maintenance freedom, long-life resistance to fire and corrosion, and ability to withstand extreme weather conditions. Color Galbestos has proven itself equal or better in every respect.

With Color Galbestos you now can have colored roofs and sidewalls at a lower cost than that possible by any other means. These new colors and the three standard corrugations shown at the right, used singly or in combination, open a new field of decorative treatment for industrial and commercial structures. Use the coupon to write for literature.



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"First time I ever used Armco Piling ...but it drove fast and straight"

So said Mr. F. R. Brown, project superintendent for H. G. Smith, contractor of Fitzgerald, Georgia. He was speaking in regard to Armco Welded Steel Pipe Piles that were used in replacing three county bridges on Georgia's State Route 119.

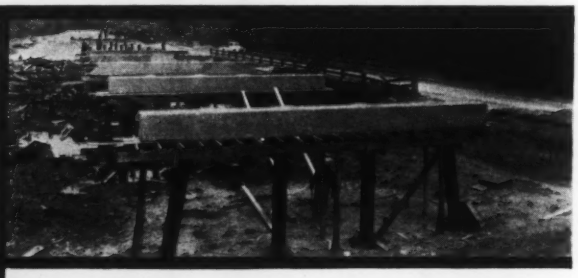
All three bridges, totaling 1500 feet in length, utilize the same basic design —bents consisting of four Armco Pipe Piles capped by a concrete beam. The two outside piles were driven on a 1½ to 12 batter while the center two piles were vertical. All of the piles were driven with a drop hammer on fixed leads.

Armco Piles Have Many Applications

Armco Pipe Piles are economical and efficient for bridges on superhighways as well as county roads. They are also widely used for foundations of buildings and other structures. You will find the right wall thickness, diameter and length for every foundation job.

Write us for more details on Armco Pipe Piles, and also ask us about Armco HEL-COR Pile Shells. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 4946 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario. Export: The Armco International Corporation.

Bridge No. 1 Armco Pipe Pile bents are almost completed for this 389-foot bridge. Old bridge at right.



Bridge No. 2 Armco Pipe Piles are ready for next step in building this 683-foot-long bridge. Note old bridge.

Bridge No. 3 As with the other bridges, this 424-foot-long structure has outside piles driven on a batter.

Contractor: H. G. Smith, Fitzgerald, Georgia

Georgia State Highway Department:
Resident Engineer, L. B. Ackerman
Project Engineer, J. I. Moore

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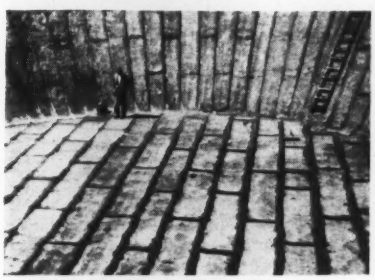
GIANT IRRIGATION CANAL for water district, Colorado.



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↓ INDUSTRIAL RESERVOIR, Texas.

Heretofore, rigid structures cracking under ground movements, or by endless cycles of contraction and expansion, was a very real engineering tragedy. But this possibility has now been eliminated in the GULF-SEAL Process of seepage-proofing canals, reservoirs and waterways.

These field-proven linings "give" to earth movements. . .are not detrimentally affected by repeated wetting and drying, heating and cooling, expansion and contraction.

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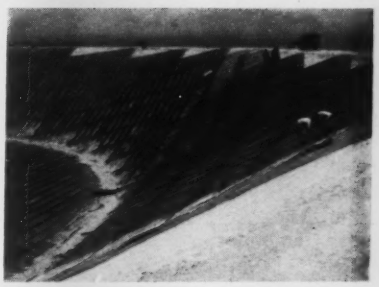
The experiences of major oil companies, large industries and municipalities fully document these claims. Mammoth industrial waterways, huge municipal reservoirs and striking canals testify to the durability, efficiency and economy of GULF-SEAL Prefabricated Asphalt Linings.

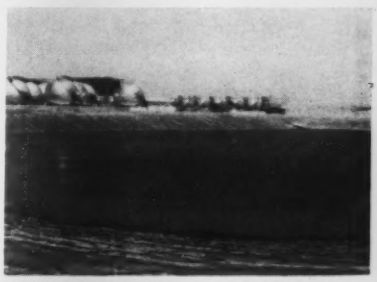
These experiences are fully set forth in our new Engineering Brochure, now in its Third Printing. It provides you with a comprehensive grasp of the materials and the technique, in seepage, pollution and erosion control.

Your copy will be mailed you promptly upon your request.

Elsewhere in this issue of CIVIL ENGINEERING is an article detailing the GULF-SEAL Method of seepage, erosion and pollution control.



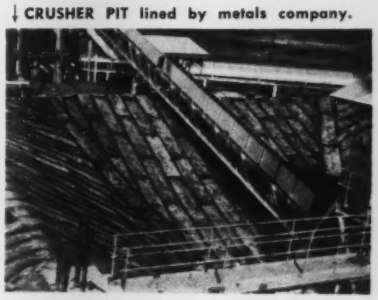
MUNICIPAL RESERVOIR, completely lined with Gulf-Seal.



INDUSTRIAL RESERVOIR, for Major Oil Company, Texas.

EROSION CONTROL on banks. ↑

↓ CRUSHER PIT lined by metals company.



WRITE FOR ENGINEERING BROCHURE!

GULF SEAL CORPORATION

Division of Gulf States Asphalt Company,

Melrose Building . . Houston 2, Texas. **Factory: South Houston, Texas.**

Civil Engineer," ASCE President Enoch R. Needles presented statistics to prove that the civil engineer, "one of the most important entities in the community," comprises one of the smallest fractions of its makeup. "In the average U.S. city of 16,500 population," he said, "there are only ten civil engineers, four of whom are members of the ASCE. Because of the distinctive position the civil engineer holds in the community, therefore, he holds the public eye, and it behooves him to gain the public respect which his duties warrant."

Wisconsin Section awards Life Membership Certificate to Nicholas M. Isabella (seated left), Madison contractor. Presentation is being made by Arno T. Lenz, professor of civil engineering at University of Wisconsin and president of Wisconsin Section. At same meeting Section presented official ASCE banner to University of Wisconsin Student Chapter. Participants in that ceremony were (standing, in usual order) Prof. James Woodburn, chairman of civil engineering department and Faculty Adviser to the Chapter; Chapter President Richard Cook; and Willard Warzyn, Contact Member for the Chapter, who presented the banner.

Mr. Needles believes that the shortage of engineers can be overcome by proper utilization of professional personnel. James Creese, president of Drexel Institute, delightfully developed the subject, "The Relationship Between the College Campus and the Professional Societies." He cited the student chapters of the technical societies for the leading role they play in awakening a spirit of professionalism in the students. In Dr. Creese's opinion, the professional societies can help to reduce the early flunk-outs of engineering students (which total almost 50 percent of entrants) by recognizing the importance of engineering education. "The challenge of keeping the freshman and sophomore interested in continuation of studies, and rigid application to the requirements of these studies, must be met," he asserted.

Current techniques for the production of reliable welds in steel structures were outlined at a meeting of the **Pittsburgh Section** on March 21. Featured speakers were LaMotte Grover, consulting engineer for the Air Reduction Sales Company, and Van Rensselaer P. Saxe, consulting engineer of Baltimore. In a paper on "Crane Girders and Mill Building Frames," presented at a meeting on March 27, John J. Murray, development engineer for the Jones and Laughlin Steel Corporation, explained a method of analysis developed by J. & L. engineers that recognizes the elements of continuity in mill building frames. Both meetings were joint sessions with the Engineers Society of Western Pennsylvania.

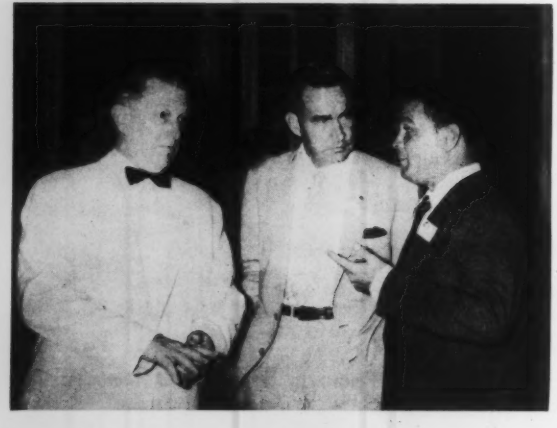
Engineers and architects in the Providence area got together recently for a joint dinner meeting that was so much enjoyed it will be made an annual affair, the **Providence Section** reports. Featured speaker was Brig. Gen. Robert Fleming, New England division engineer for the Corps of Engineers, who discussed measures taken for the hurricane protection of Narrangansett Bay.

At the helm of the **Sacramento Section's Central Valley Branch** are Edward L. Tinney, president; P. H. Van Etten, vice-president; Warren D. Noteware, secretary; and Ed Labrie, treasurer. **Marysville Branch** officers are Paul C. Sheridan, president; George Reed, vice-president; Tom Lammers, secretary; and Ed Whitnack, treasurer. Causes and effects of the disastrous Christmas week floods in the Sacramento Valley were interestingly discussed at the March meeting of the Marysville Branch by two officials from the Sacramento District of the Corps of Engineers—H. E. McGee, special assistant to the chief, Engineering Division, and W. A. Doyle, assistant chief, Planning and Reports Branch.

A change in the roster of new **Seattle Section** officers (April issue, page 87) is announced. George R. Herrin replaces Nolan Daines as secretary. His address is Corps of Engineers, Alaska District, SBRO, 4735 East Marginal Way, Seattle 4, Wash.

Recently elected officers of the **Southern Idaho Section** are Francis C. Hart, president; John D. Griffiths and Lynn Crandall, vice-presidents; Claude H. Studebaker, secretary; and Robert H. Griffiths, treasurer.

Of special interest in the power-hungry Northwest was the **Tacoma Section's** March meeting, which dealt with fish-passage facilities for the Tacoma City Light's Mayfield Dam on the Cowlitz River. The Cowlitz River dams have been a controversial issue in the state for nearly a decade, but are now under construction despite opposition from fishery and navigation interests. The fish facilities were well described by Section members H. Frankland Smith and Stuart M. Alexander. A highlight of the evening was a surprise visit from ASCE Vice-President Glenn W. Holcomb, who reported Board activities at the Dallas Convention.



Seen at Engineers' Day reception at Union Club in Panama are (left to right) Brig. Gen. John S. Seybold, M. ASCE, governor of Canal Zone; Hugh M. Arnold, president of Panama Section; and Celso A. Carbonell, M. ASCE, president of Panama Society of Engineers and Architects. These two groups and Society of American Military Engineers were sponsors for first formal observance of Engineers' Day on the Isthmus. During the week of March 2 the three societies sponsored a program to enccurage high school and junior college students to become engineers.

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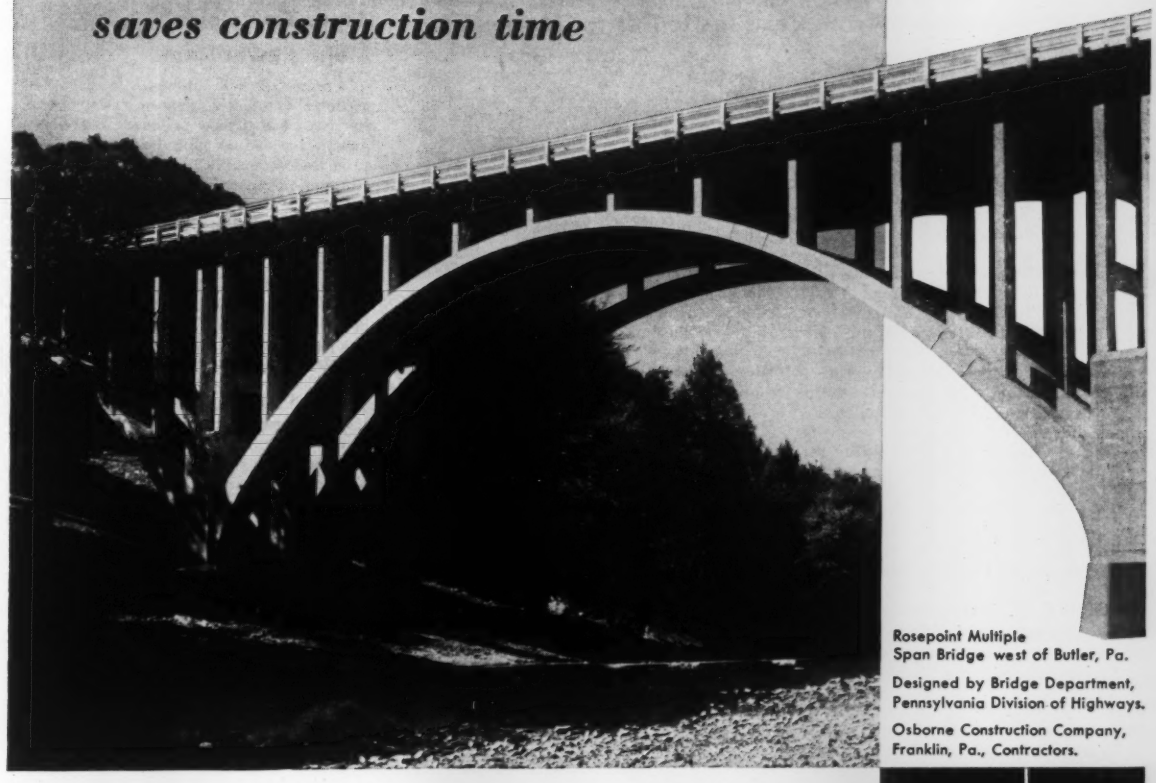

Rosepoint Multiple Span Bridge west of Butler, Pa.

Designed by Bridge Department, Pennsylvania Division of Highways.

Osborne Construction Company, Franklin, Pa., Contractors.

Make your bridge appropriation dollars go further with reinforced concrete. Time and again, comparison cost studies have proved the economy of reinforced concrete. Equally important, reinforced concrete bridges and overpasses start sooner . . . go up faster, because all necessary materials can be delivered *in a matter of days* from local stocks. These faster starts, plus the faster construction made possible with reinforced concrete, save months of delay.

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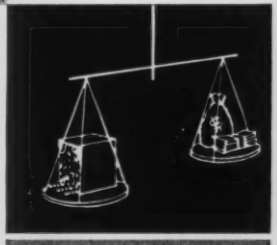

CONCRETE REINFORCING STEEL INSTITUTE

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NEWS BRIEFS . . .

AISC Conference Promotes Plastic Design Method

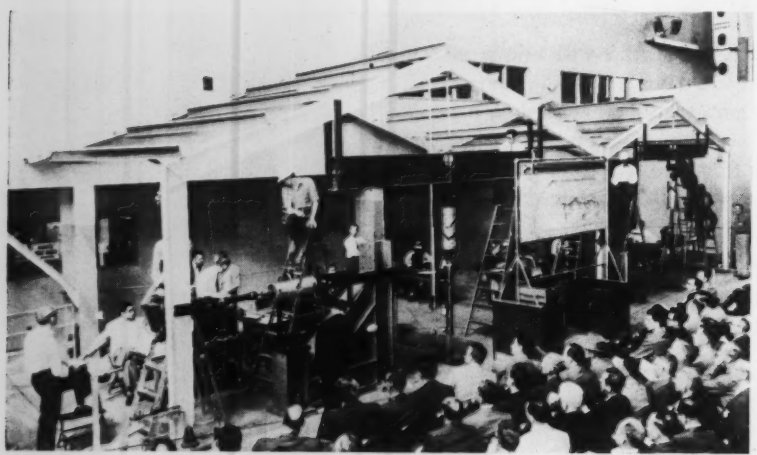
Adoption of the plastic method of design was strongly endorsed at the recent Eighth Annual Engineering Conference of the American Institute of Steel Construction, which was attended by more than 300 designers, fabricators, and educators. The conference was held at Lehigh University, where the accuracy of the design method was dramatically demonstrated in the university's Fritz Engineering Laboratory. In speaking of plastic design Earle V. Grover, president of AISC, stated that it is based on the analysis of the true maximum strength of the continuous frame as contrasted with an analysis limited to its elastic behavior.

The design methods outlined at the meeting make extensive use of charts and graphs developed during ten years of research at the university. Basically the method assumes the development of plastic hinges in rigid frames, thereby bringing more of the steel capacity into play. From the assumed loading, conditions of support, and frame proportions, certain basic and easily computed relationships can be found. By entering these factors in the appropriate chart, other unknowns can be found whereby the maximum moments and the locations of the plastic hinges can be computed by simple mathematics. It is an easy matter then to investigate for critical loadings and choose the proper steel section. The tables and equations are developed to give as great a factor of safety as in elastic design with load factor and shape factor taken into account.

The method, it can be seen, cuts design time as much as 75 percent on indeterminate rigid frames. The greatest savings in material are realized where horizontal loads are significant in relation to the dead loads. However, material savings are not always the most significant advantage. It was also pointed out that any work in tension areas of the plastic hinge, such as punched holes, could have deleterious effects on the fluidity of the hinge.

The results of Lehigh's ten-year research program were reported by Lynn Beedle, A.M. ASCE, Dr. Bruno Thurlimann, and Robert L. Ketter, J.M. ASCE, all members of the civil engineering faculty. Application of plastic design was discussed by Walter Weiskopf, M. ASCE, New York City consultant, and Prof. F. W. Schutz, Jr., J.M. ASCE, of Georgia Institute of Technology.

A design manual in the plastics field is currently in preparation by AISC and will be published within the year.



Full-scale rigid-frame bent is tested with concentrated loads at the quarter points of each gable during three-day AISC convention at Lehigh. Near span is 30 ft and far span 20 ft. Chart at right shows computed curve of relation of load to deflection of mid-point of near gable. Actual relationship is plotted on chart during application of load through electrical gauges and relays.

Japan Completes Major Power Dam

This May last concrete is being poured for Sakuma Dam, in central Honshu, Japan, forerunner of a large-scale power program that will be in operation this summer. Located on the Tenryu River between Tokyo and Osaka, the nation's leading industrial cities, the 492-ft-high dam is the tallest in Japan and the seventh highest in the world. Its completion in two and a half years instead of ten, as originally estimated, is being hailed as a construction miracle.

Credit for the project is also given to Tatsunosuke Takasaki, first president of the Electric Power Development Company, which was organized in 1952 to meet the critical power shortage developing at that time. It was Mr. Takasaki who selected the dam site, despite considerable opposition from Japanese engineers, and employed the Guy F. Atkinson Company, of San Francisco, to act as consulting engineer on the project. The Tenyru drops 2,500 ft in its 100-mile course through granite ridges, and it changes in volume from a mere trickle in the dry season to a flow more than half that of the Columbia River in the rainy season (about 150,000 cfs). In addition to building the dam and powerhouse, the project included shifting a railroad line and carving a six-mile road out of the side of a cliff.

When the Sakuma Power Station is in full operation this summer, it will increase Japan's generating capacity by 350,000 kw. The cost of the dam and powerhouse has been about $92,000,000, instead of the $72,000,000 originally estimated. Some $60,000,000 of this is American money, which will be repaid.

Savannah to Have New Power Plant

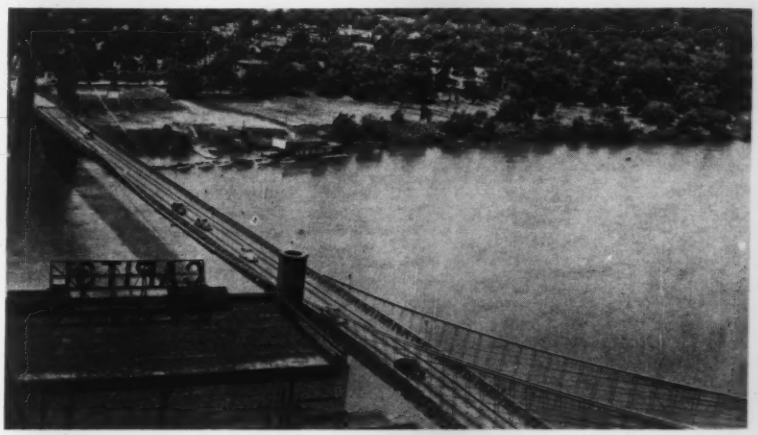
The Savannah Electric and Power Company has authorized the Stone & Webster Engineering Corp., Boston, to design and construct the first unit of its new electric generating station on the Savannah River at Port Wentworth, Ga. Of the semi-outdoors type featuring an outdoor boiler and enclosed turbine room, the new station will have an initial capacity of 50,000 kw. Completion in March 1958 is planned.

Wheeling Bridge to Be Rededicated as Memorial to John A. Roebling

In ceremonies set for May 20, the Wheeling, W. Va., suspension bridge over the Ohio will be rededicated as a national memorial to John A. Roebling and to engineers generally. With a main span of 1,010 ft, the Wheeling Bridge was the longest suspension crossing in the world at the time of its completion in 1860 and now, after almost a century of continuous service, it is the oldest existing suspension bridge.

The present span, designed and built under the supervision of John A. Roebling, replaced an earlier suspension structure, which was completed in November 1849 and destroyed by wind five years later. Charles Ellet, Jr., a contemporary of Roebling and fellow exponent of the suspension type of bridge, was the designer of the original crossing, which was financed by the Wheeling and Belmont Bridge Company.

Principal speaker at the rededication ceremonies will be D. B. Steinman, M. ASCE, modern authority on the suspension bridge as well as on the life and work of Roebling. In *Bridges and Their Builders*, Dr. Steinman says that the Wheeling Bridge well exemplifies the difference between Ellet's and Roebling's method of fastening wire cables. Ellet, he says, "laid his wires in separate strands side by side, then connected these parallel strands by iron bars from which he hung the suspenders. Roebling squeezed his strands together to form compact cables of cylindrical shape, then wrapped the cables with light wire, hanging the suspenders from iron clamps that encircled the cable. Roebling's method provided improved protection for the wire from the weather, greater unity and strength for the cable, and a better means for fastening the suspenders."

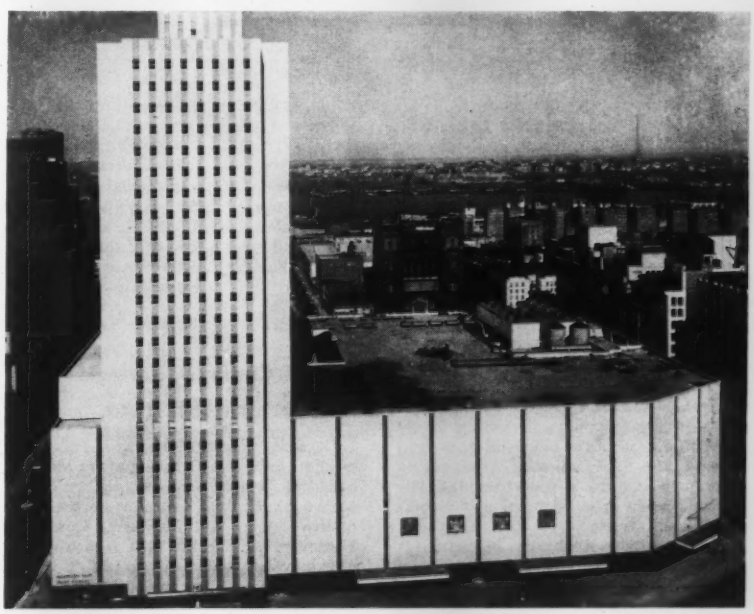


Century-old suspension span, dating back to the period when West Virginia was still part of Virginia, is being rededicated as memorial to its builder, John A. Roebling, in ceremonies this May. The veteran structure is still an important east-west traffic link. It is 28 ft wide between suspenders and 62 ft above high-water level. The original cost was $42,000.

The West Virginia State Highway Commission is making repairs on the bridge, which will be completely overhauled after the dedication. A working committee, under sponsorship of the West Virginia Society of Professional Engineers, is in charge of plans for the memorial rites. It consists of Paul J. McCullough, engineer, Cadiz Water & Sewage Department; Albert Neroni, advertising manager, John A. Roebling's Sons Corp.; Otis Bledsoe, Hanna Coal Company; R. S. Carnahan, personnel director, Wheeling Steel Corporation; and M. D. Ayres, chief engineer, Wheeling Steel Corporation. The memorial will be in the form of a large bronze tablet provided by John A. Roebling's Sons Corporation, Trenton.

New York Coliseum Opens on Schedule

New York's great new $35,000,000 convention and exhibition center opened on April 28 with three shows running concurrently. It consists of four exhibition floors (over 300,000 sq ft); a 20-story-tower office building atop the exhibition hall; and garage space for 850 cars on two basement levels. Owned by the Triborough Bridge and Tunnel Authority, the Coliseum was built with the idea of attracting to New York a larger share of the nation's trade-show business. It was constructed as a joint venture by the Walsh Construction Company, the George A. Fuller Company, and the Slattery Contracting Company. Leon and Lionel Levy were the architects; Jacob Feld, M. ASCE, the structural engineer; and Guy B. Panero Engineers, the mechanical engineers. Dr. Feld described the construction techniques that made it possible to complete the vast project in two years in the July 1955 issue (page 33).



New Carquinez Strait Bridge Under Construction

Construction of the new Carquinez Strait vehicular crossing, authorized by the California State Legislature in June 1955, is in full swing. Located parallel to the existing Carquinez Bridge, the new crossing will carry northbound, and the existing structure southbound, traffic between San Francisco and Sacramento. When completed late in 1958, the bridge and its Contra Costa County approach will eliminate the last and most serious traffic bottleneck between these busy and populous areas.

The new structure—providing for four lanes of traffic on a 52-ft clear roadway width supported by two trusses 60 ft apart—will involve much heavier construction than the existing three-lane structure, which is but 42 ft wide. Notable design features include the use of high-strength bolts instead of rivets for field connections at the truss joints; fabrication of the heavy truss members and floor beams by welding; and the use of a new high-strength weldable steel almost three times as strong as the structural steel ordinarily used in bridge construction.

Construction of the substructure will also be difficult, involving the sinking of three large concrete caisson piers to bedrock some 135 ft below the surface of turbulent water. The sinking operation will take several months, and the cost of the three caisson piers will come to more than $1,000,000 apiece. The substructure will also include the construction of two shore piers and one water pier, 50 ft wide by 113 ft long, founded on 260 steel bearing piles driven to bedrock.

The Contra Costa County Freeway approach is called exceptional "not only because of the amount of money involved [$7,098,690] but because it includes the largest cut ever undertaken by the Division of Highways." The "Big Cut" at Crockett includes excavation of 8,500,000 cu yd. Depth at the largest section of the cut varies from 245 ft at the center line of the roadway to 350 ft at the side. The width at the top is 1,370 ft, and the total length 3,000 ft.

The substructure contract is being handled by a joint venture consisting of Mason and Hanger, Silas Mason Co., Inc., and F. S. Rolandi, Jr., Inc., who were low bidders at $5,454,694. The U. S. Steel Corporation, with a low bid of $9,489,126, has the contract for fabricating and erecting the steel superstructure. The Contra Costa County approach is being built by a joint venture of Glendale, Calif., contractors—Ferry Brothers, John M. Ferry, Peter L. Ferry, and L. A. and R. S. Crow—who were low bidders at $7,098,690. Leonard C. Hollister, M. ASCE, is projects engineer on the work for the Department of Public Works Division of Highways.

New Carquinez Straits Bridge is being built 200 ft upstream from the existing bridge. It will be similar in span length and shape to existing structure, but will have wider roadway. Project will feature several recent developments in bridge design and material. Toll plaza will be at Vallejo (lower right).

Pittsburgh Breaks Ground For Large Treatment Plant

Formal ground-breaking ceremonies for the long-pending Pittsburgh Sewage Treatment Plant took place on April 4. Under study for more than 40 years, the new project is designed to serve Pittsburgh and 63 of its suburbs for an estimated population of 1,400,000 in 1970 and 1,650,000 by the year 2000. It consists of a 150-mgd sewage treatment plant, providing for 50 percent removal of the biochemical oxygen demand and 63.5 miles of intercepting sewer (half of them in deep tunnel). The present project is an adaptation of recommendations made by the Allegheny County Sanitary Authority in 1948. It consists of more than 20 plants instead of the single treatment unit originally proposed.

The new plant was discussed in detail in the January 1954 issue (page 44) by John F. Laboon, M. ASCE, executive director and chief engineer of the Allegheny County Sanitary Authority.

End of Cement Shortage Forecast for This Year

Capacity increases achieved by the cement industry should put production ahead of demand by late July, according to W. A. Wecker, president of the Marquette Cement Manufacturing Company. However, Mr. Wecker warns that the rush of expansion programs, touched off by the heavy demand for cement in 1955, may also have adverse effects. In the company's annual report, he points out that "In the haste of planning so much new capacity it was inevitable that not all projects would be well conceived. There are already indications that capacity in some areas may be more than needed."

Ample cement supplies in 1957 for the eighteen-state market served by Marquette's eight producing plants are assured by tremendous new capacity begun last year. Marquette and other companies producing for the Midwest and Southeastern states are expected to spend a quarter of a billion dollars to increase annual capacity by 35,000,000 barrels, 29 percent more than at the start of 1955. Marquette's current expansion program, which includes construction of two entirely new plants at Milwaukee and Cape Girardeau, Mo., will add 3,000,000 barrels to its present annual capacity of 13,500,000 barrels.

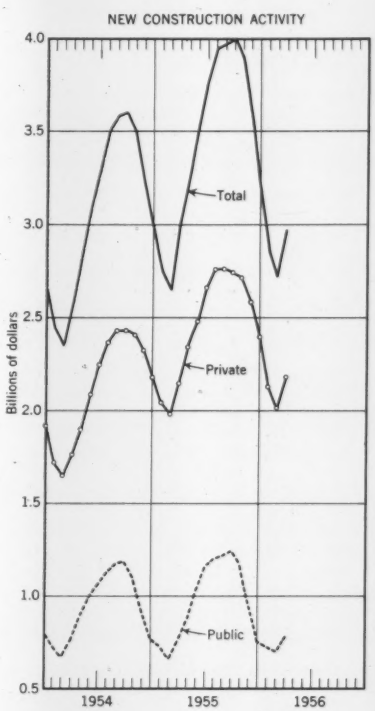
First-Quarter Construction Matches Record Set Last Year

The value of new construction put in place this past March rose seasonally to $2.98 billion, equalling the previous March record set in 1955, according to preliminary joint estimates of the U. S. Departments of Commerce and Labor. For the first three months of this year construction activity amounted to $8.5 billion, the same figure reported for the first quarter of 1955.

Residential building activity rose seasonally in March to $1.1 billion. Although this was about 6 percent below the extraordinary March 1955 figure, it exceeded the March volume for all other years. Private nonresidential building set a new March record as industrial construction reached an all-time high. A 7 percent increase over February in the building of stores more than offset a drop of 4 percent in office buildings and warehouses, and sent the commercial building total to a new high for the month.

Public construction outlays in March advanced 16 percent from February, with all major types of construction except public housing contributing to the increase. Expenditures were greater than in any previous March for highway construction, public educational building, and sewer and water works.

Although total new construction activity in the first quarter of 1956 was the same as that for the first three months of 1955, several of the major types showed significant changes. Decreases this year in private residential building and in public industrial work were offset by increases in commercial building, private industrial construction, highway work, and public service enterprises.



March construction figure, at $2.98 billion, represents seasonal rise over February and equals record for the month set in 1955.

Clifty Creek Power Plant Goes on Line

The Clifty Creek power plant, largest private power station in the world, has been completed well ahead of schedule and is now in full operation. With the last of its six 215,000-kw generating units on the line, the Clifty Creek plant has a total generating capacity of 1,290,000 kw—more power than the entire nation of India consumes in a year. The combined capacity of the new station and its recently completed sister project, Kyger Creek, is 2,365,000 kw, which is about one-third of France's annual generating capacity.

Builder-owner of the two facilities is the Ohio Valley Electric Corp., consisting of fifteen electric utility companies in the area and headed by Philip Sporn, M. ASCE, as president. A 330,000-v transmission network links the two stations to the power systems of the sponsor companies and the Portsmouth (Ohio) project of the Atomic Energy Commission.

A comprehensive article on the Clifty Creek and Kyger Creek steam-generating plants by Mr. Sporn and his vice-president, H. A. Kammer, A. M. ASCE, appeared in the August 1954 issue of CIVIL ENGINEERING.

Many U. S. Cities In Need of Water

More than one in four of the larger urban areas of the United States will need additional water supplies to meet municipal and industrial growth. Announcing the results of a nationwide survey of 1,532 communities, the U.S. Public Health Service reports that 367 areas, with a total population of nearly 20,000,000, state that they will need additional supplies.

Adequate treatment of wastes to permit more extensive use of available surface water is seen as the logical answer to some of the present supply problems by Gordon E. McCallum, chief of the Service's Water Supply and Water Pollution Control Program.

The inventory covered all facilities serving a population of 10,000 or more and a 40 percent sample of those serving between 5,000 and 10,000. It was carried out by a delegation under the Office of Defense Mobilization as part of the government's mobilization-readiness planning activities.

Asphalt Turnpike Called Sound Investment Risk

Modern asphalt-paved toll roads are showing a solid record of earnings, according to a survey recently completed by the Asphalt Institute. The survey shows that in four states asphalt turnpikes, ranging in age from three to eight years, are piling up comfortable reserves after meeting operating and maintenance costs and bond service. The survey further disclosed that the performance of the heavy-duty asphalt pavement has, in every case, been satisfactory. A limited amount of surface raveling was reported on the Turner (Oklahoma) Turnpike, but this was easily and quickly corrected by sealing.

Cited as "most conspicuously successful" was the 118-mile New Jersey Turnpike. "In four years the turnpike has carried an astonishing volume of 90,992,781 cars, trucks, and buses without any structural failure in the pavement, according to J. E. Buchanan, M. ASCE, president of the Institute. The other asphalt-paved toll roads studied were the Maine and New Hampshire turnpikes.

Applied Mechanics Congress To Be Held in Brussels

The Ninth International Congress of Applied Mechanics will be held at the University of Brussels, Brussels, Belgium, September 5–13, according to an announcement from the American Society of Mechanical Engineers. Brochures on the congress are available from the Secretary of the ASME, 29 West 39th Street, New York 18, N. Y.

Technical sessions will cover the fields of fluid dynamics, aerodynamics and mechanics of solids (rigid dynamics, vibrations, elasticity, plasticity). In addition to these sessions, there will be lectures of general interest.

The American Express Company has been designated official travel agency of the congress. Registration will be handled at any of the company's offices throughout the country. Admission to the applied mechanics sessions is $4.00.

American Concrete Pipe Association Has Annual Convention

Despite the beautiful surroundings of the Broadmoor Hotel at Colorado Springs, where the recent 48th annual convention of the American Concrete Pipe Association was held, the 250 delegates to the convention concentrated on the needs of the industry in a week-long program of technical discussions and administrative meetings. There were no formal papers.

Richard D. Pomeroy, M. ASCE, consulting engineer of Pasadena, Calif., talked on predicting sulphide buildup in sanitary sewers and on the reaction rate of certain acids on various construction materials. According to Dr. Pomeroy, the formation of hydrogen sulphide in sewers is predictable. In most sewers it is not present at all, or is present only intermittently and in very small amounts. Although the presence of hydrogen sulphide is undesirable, a few hundredths of a part per million of dissolved sulphide, when converted to sulphuric acid under certain definite conditions, will not adversely affect concrete structures or will affect them only to the extent of a few tenths of an inch per century.

Dudley Babcock, engineer with the Bridge Division of the U. S. Department of Public Roads, explained and discussed a paper he had presented to the Highway Research Board in January on a "Simplified Design Method for Reinforced Concrete Pipe Under Earth Fills." The Design Committee of the American Concrete Pipe Association met for a day and a half to discuss coordination of designs for pipe to meet the requirements of the specifications as proposed by Mr. Babcock. These designs, when completed, will be presented to ASTM Committee C-13 for consideration and adoption in the specifications for concrete pipe.

A subject discussed at some length was the relationship between the ASTM three-edge bearing test which has been required for a number of years to measure the strength of pipe in the laboratory and the recently adopted core tests, by means of which cores are cut from the wall of the pipe and tested for compressive strength. The pipe under this test is accepted on the basis of proper placement of reinforcement, the strength of the concrete, and compliance with the minimum absorption test requirements. The importance of proper capping of cores prior to testing, in order to obtain the true strength of the concrete, was emphasized.

Carl A. Bluedorn, president of the Zeidler Concrete Products Machinery Company, of Waterloo, Iowa, was elected president of the association for 1956. E. F. Bespalow, M. ASCE, of Memphis, Tenn., was reelected vice-president, together with Harry W. Heath, of East Orange, N. J. C. M. Adams, of South Gate, Calif., was elected new vice-president; John H. Bailey, of Elk River, Minn., secretary; and Craig J. Cain, of Chicago, treasurer.

Howard F. Peckworth, M. ASCE, is managing director of the American Concrete Pipe Association, which has its headquarters at 228 North LaSalle Street, Chicago 4.

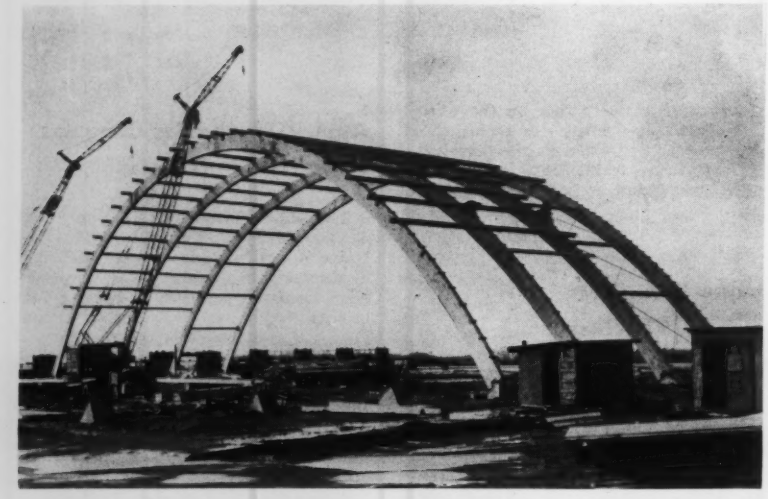
New Bridges for Chicago's Northwest Expressway

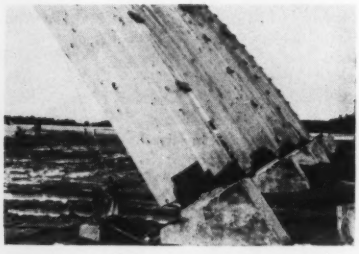
Two bridges that will carry Chicago's Northwest Expressway over Hamlin and Keeler Avenues in Chicago are being designed by the Stanley Engineering Company, of Muscatine, Iowa, and Chicago. The expressway is a 16-mile route extending from the Congress Street Expressway in downtown Chicago to the northern limits of the city. It consists of two main roadways, each with four 12-ft traffic lanes.

Brazil Orders Atomic Research Reactor

The Babcock & Wilcox Company will build and install a swimming-pool-type of atomic research reactor for Brazil's Comissao de Engergia Atomica, the Brazilian equivalent of the U. S. Atomic Energy Commission. Fuel to operate the reactor will be furnished by the AEC under one of 25 recent bi-lateral agreements between the United States and friendly governments. It is designed to operate at a power level of 5,000 kw of heat output, the highest-rated swimming-pool type of unit yet announced. The reactor will probably be located at the University of Sao Paulo.

West Coast Hangar Features Clear-Span Construction





Erection of arches for hangar under construction near Everett, Wash., is shown here. Located at the Snohomish County Airport adjoining Paine Air Force Base, the hangar is 210 ft in span and 200 ft long. It is of clear-span construction, framed by eleven glued laminated arches of 210-ft span and 54-ft 7-in. center height. A 30-ft lean-to storage and office bay adjoins the hangar, with one end of the framing beams supported by the arches. T. M. Carstensen Company, of Seattle, is the designer, and the Shaffer Construction Company, of Everett, the general contractor. Timber Structures, Inc., laminated and erected the arches.

Rx Making sick wells . . . WELL!

First comes diagnosis. Before the cure the trouble must be known so that proper treatment may be prescribed.

Trained Layne research men, with the help of the latest and best in scientific equipment, find the trouble . . . determine the corrective measures . . . and experts go to work.

Successful? . . . One smaller Southern city saved the cost of a new well at a nominal cost. And that's just one success in a long line of sick wells that have been made well by Layne.

The nearest Layne associate company will be glad to discuss such problems with you—without obligation. It's another Layne service that proves it's always wise first to "ASK THE MAN FROM LAYNE" on any phase of water development or maintenance.

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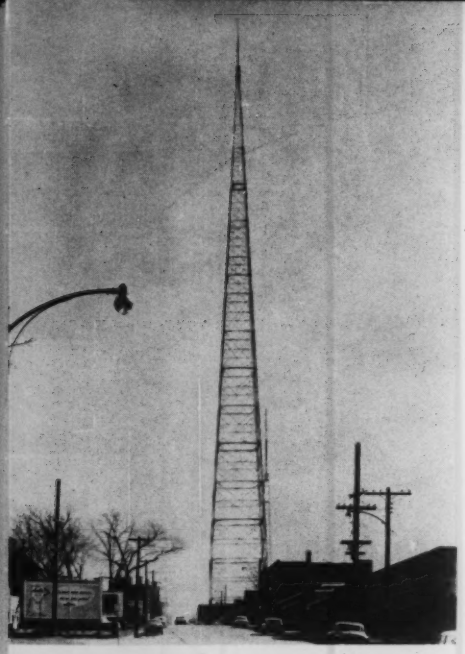


Kansas City Has Tallest Self-Supported TV Tower

Better picture projection over a wider area is the good news for TV fans in Kansas City, Mo., where the world's tallest self-supported TV tower was recently dedicated. The new facility, which increases KCMO-TV's visual signal from 71,000 to 100,000 w and audio to 60,000 w, is 1,042 ft high—taller than the Eiffel Tower and almost twice the height of Washington Monument. The 99-ft antenna has automatic sleet-melting equipment. Construction, involving placing 800 cu yd of concrete and 600 tons of steel, was completed in slightly over a year despite many days of bad weather. The builder was C. H. Fisher & Associates, of Portland, Ore.

Prefabricated Asphalt Lining for Water Tanks

Successful use of prefabricated asphalt lining to control seepage and erosion in the containment and transportation of water is reported. Applications of the new technique range from Dollarhide, Tex., where a salt-water reservoir measuring 700 by 250 ft, with wall slopes of 40 ft, was successfully waterproofed after two previous failures with other materials, to Morgantown, Pa., where the sheets were used to line the entire length of a two-mile ditch.

Developed by the Gulf Seal Corporation, a division of the Gulf States Asphalt Company, South Houston, Tex., the lining is 3 ft wide and $1^1/_2$ in. thick, factory-cut to any length up to 14 ft. Its weight is about 3 psf, and its specific gravity 1.2. The plastic material has a flexibility and "give" which enable it to withstand ground movement. Repeated cycles of heating and cooling, wetting and drying, contracting and expanding—often injurious to rigid, monolithic structures—have no detrimental effect on it.

The high-speed installation technique calls for the following sequence of operations. The sheets are spotted in approximate position from a trailer, then lined up, side by side and end to end. Next both the adjacent edges and a 6-in.-wide covering strip are hot mopped with a special adhesive. The strip is placed over the joint and sealed by foot pressure. A follow-up crew, using a cold adhesive, "repoints" all seams and overlaps.

Sheets are laid to overlap the berm by 2 or 3 ft on large reservoirs or canals, and by lesser amount on ditches. The edges only are staked into the ground and then covered with a light backfill. Unlike lighter materials, the submerged sheets need not be covered with backfill.

This 700 by 250-ft reservoir for natural gas plant at Dollarhide, Tex., was successfully waterproofed with prefabricated asphalt lining against seepage and erosion after two previous failures with other materials.

American Welding Society Elects New Officers

John J. Chyle, director of welding research for the A. O. Smith Corp., has been elected president of the American Welding Society for the 1956–1957 fiscal year, beginning June 1. The new vice-presidents will be Clarence P. Sander, general superintendent of the Vernon Plant of the Consolidated Western Steel Division of U. S. Steel, and Gustav O. Hoglund, head of the Welding Section, Alcoa Process Development Laboratory, Aluminum Company of America.

Names Replace Numbers In Lumber Grading

A new system of names instead of numbers to denote lumber grade has been adopted by the West Coast Lumbermen's Association. In the new nomenclature, the designations will be: Construction (formerly No. 1); Standard (formerly No. 2); Utility (formerly No. 3); and Economy (formerly No. 4). A number of minor changes have also been made in grades.

The new method of identification has been adopted in response to the request of retail dealers, government agencies, builders, and others who are of the opinion that the numerical system of designation has hampered the sale of the lower grades of lumber. As explained by H. V. Simpson, executive vice-president of the West Coast Lumbermen's Association, the consumer is naturally reluctant to "purchase a 'third grade' product for a home which he visualizes as 'first grade' in every respect."

Newark Bay Bridge On Turnpike Opens

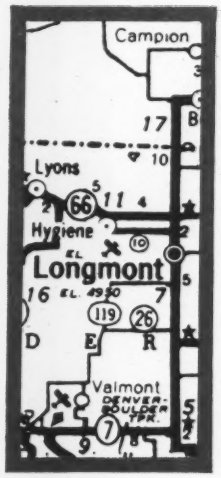
A two-mile bridge over Newark Bay between Hudson and Essex Counties—an initial section of the 8.2-mile spur of the New Jersey Turnpike from Newark Airport to the Holland Tunnel—was opened to traffic on April 4. Built at a cost of about $14,500,000 a mile, the section was described as one of the most expensive highway extensions in the country. However, Turnpike authorities expect that some 15,000,000 vehicles will use the extension each year and that it will show a profit. The Hon. Robert Meyner, governor of New Jersey, was the principal speaker.

When the full length of the extension is opened in July, it will cut in half the 30-minute driving time between Newark Airport and downtown New York.

STANDARD MC-3 Cut Back Asphalt is applied to Boulder County Highway 10. Standard Asphalt engineer Oscar Jones (left) and Highway Superintendent Douglas N. Stewart check application.

Ordering STANDARD Asphalt

makes job easier for Boulder County Highway Department



As the link between Longmont and State Highway 66, Boulder County Highway 10 gets plenty of traffic. To take this traffic, road is surfaced with STANDARD Asphalt.

Boulder County Highway 10 in Colorado links the city of Longmont with State Highway 66 three and a half miles to the west. It is a popular highway for travel to Rocky Mountain National Park and for farm-to-city traffic. Maintenance of this highway in first class, all-weather condition is made easy by the use of STANDARD Asphalt. The Boulder County highway department gets these benefits from ordering asphalt requirements from Standard: (1) top quality product and (2) an assured source of supply.

And there are still more advantages to ordering asphalt from Standard Oil. Standard's experienced asphalt salesmen know the needs of road builders and are qualified to work with them in planning requirements. Standard Oil has long experience as an asphalt supplier, knows what it means to protect customers on supplies and deliveries.

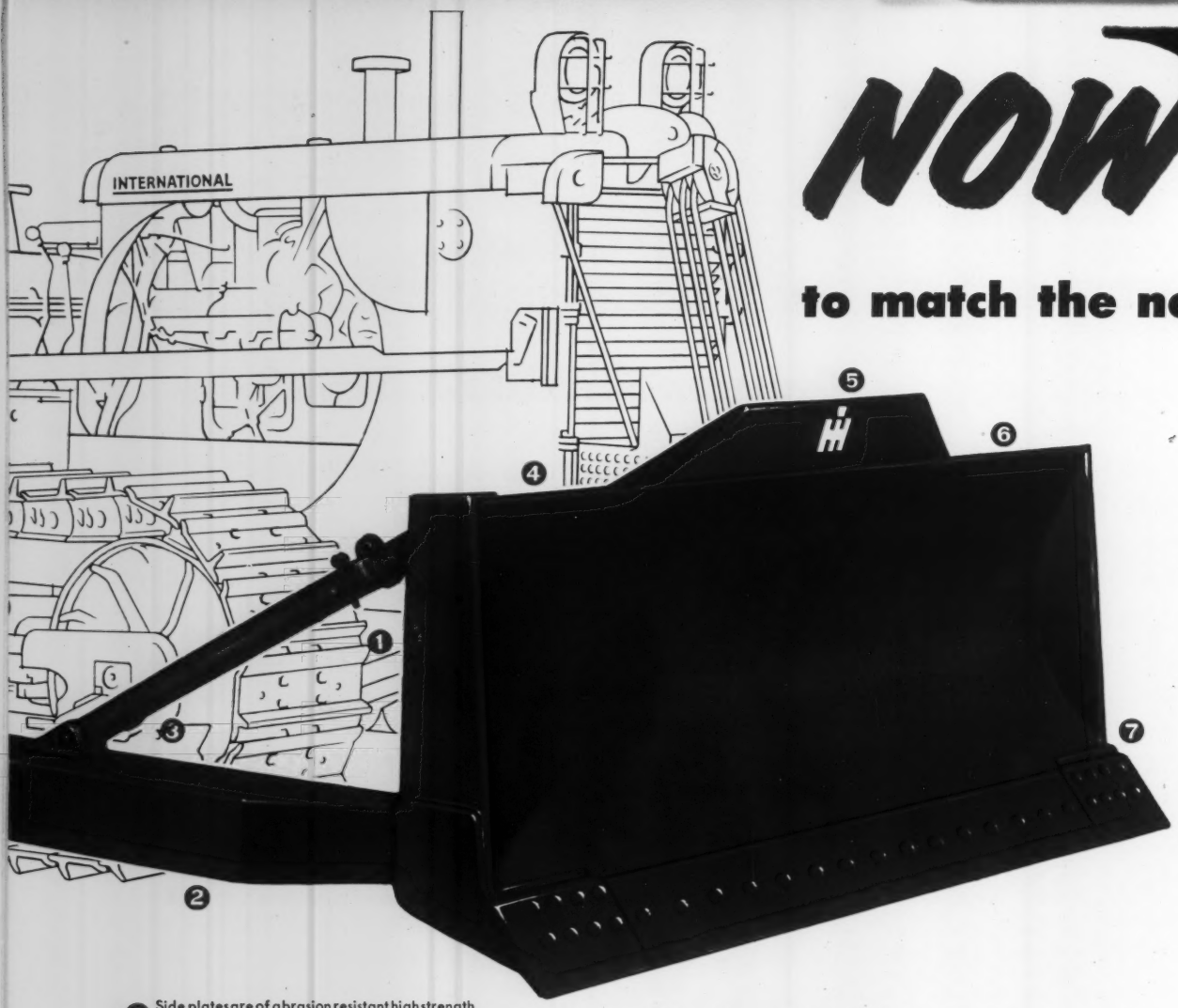
You can get these advantages when you buy asphalt from Standard. Find out. Call your nearby Standard Oil Office in any of the 15 Midwest and Rocky Mountain states, or contact Standard Oil Company, 910 South Michigan Avenue, Chicago 80, Illinois.

STANDARD **STANDARD OIL COMPANY (Indiana)**

Highway 10 running west of Longmont, Colorado to State Highway 66 is 24 foot wide, asphalt surface, all weather highway. Standard Oil's Oscar Jones and Highway Superintendent Douglas N. Stewart inspect road recently resurfaced.

NOW.

to match the new



1. Side plates are of abrasion resistant high strength steel, securely fused to moldboard and box sections by low-hydrogen welding. They prevent load spillage, allow you to carry larger loads. Standard on all International bulldozer blades.
2. Push arms are sturdily constructed of box sections. Side plates are mill-rolled with integral back-up bars to support top and bottom plates. Machine welding guarantees uniformity of weld.
3. Headless pins, locked by eye bolts, secure struts to blade. For removal, pins can be driven out in either direction. On hydraulic blades, all control linkage is connected to the blade through self-aligning bearings.
4. Entire perimeter of blade is backed by heavy box channels solidly fused to moldboard. With this type of construction moldboard, box channels, and welds flex freely to prevent weld failure.
5. Spillboard is wide and high to prevent spillage over top of blade. Note that it is curved to match the contour of the moldboard, thus aiding boiling action. Width of moldboard allows you to carry full load for which the blade was intended.
6. Moldboard is formed from a single sheet of low-alloy, high-strength steel. International blade is shaped to perfect curvature in a special forming machine to assure uniform strength and stress resistance over entire area.
7. Shear bars welded to moldboard support end bits and relieve stress on end bit bolts. Lower edge of end plate is reinforced by wear plate to add strength at corners, increase wear resistance.

New blades designed from "ground" up

To make full use of the greater work capacity of the new Bonus-Powered International crawler tractors, we now offer a complete line of newly designed blades matched to tractor power.

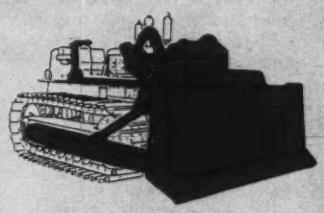
These new blades are rigidly supported around the edges by box sections to give the blade strength but also permit the moldboard to "breathe" under load stresses. New automatic welding processes guarantee that the welds in International blades will hold up under *any kind of job conditions*.

International blades will last far longer and give you far less trouble than any others you have ever hung on any tractor. When you inquire about the new line of Bonus-Powered International crawler tractors, ask your International Industrial Power Distributor for all the facts about the new line of matching blades. See for yourself that they are the best designed, best constructed on the market.

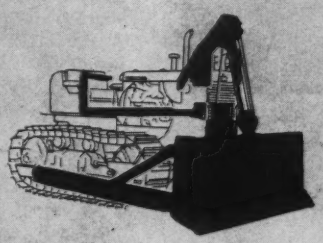
Write For New Blade Literature: An illustrated specification list of the *228* attachments available for International crawler tractors is just off the presses. For your free copy of Mailing Folder CR-492-F, write Consumer Relations Department, International Harvester Company, 180 North Michigan Avenue, Chicago 1, Illinois. No obligation, of course.

.42 new blades

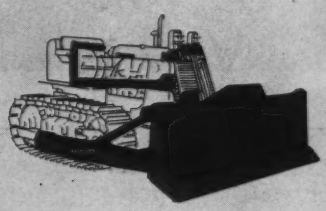
Bonus-Powered International crawlers



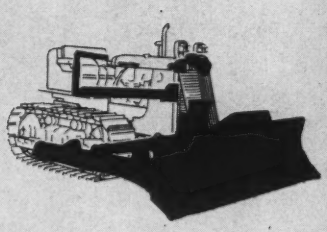
Direct Lift Hydraulic Bulldozer
Operates off front-mounted, gear-driven pump which gives fast blade action. Self-aligning bearings prevent binding of linkage.



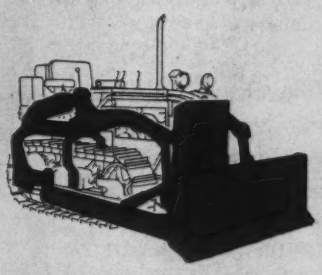
High-Gantry Cable Bulldozer
Operates off either front or rear-mounted International cable control unit. Available for TD-24, TD-18, and TD-14 tractors.



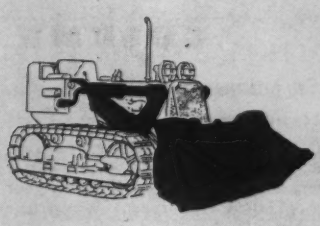
Low-Gantry Cable Bulldozer
Operates off either front or rear-mounted International cable control units. Available for TD-24, TD-18, and TD-14 tractors.



Hydraulic or Cable Bullgrader
Operates off high or low gantry, front or rear cable controls on TD-24, TD-18, and TD-14 tractors. Hydraulic bullgrader also for TD-9, TD-6, and T-6 tractors.



Track Frame Mounted Bulldozer—Distributes the load evenly over the length of the tracks. Available only for TD-9, TD-6, and T-6 tractors. Bullgrader also available.



International Drott "4-in-1"
Newest of International Drott loaders. Combines Skid-Shovel, Bull-clam, clamshell, and bulldozer in one unit. Available for TD-14, TD-9, and TD-6 tractors.

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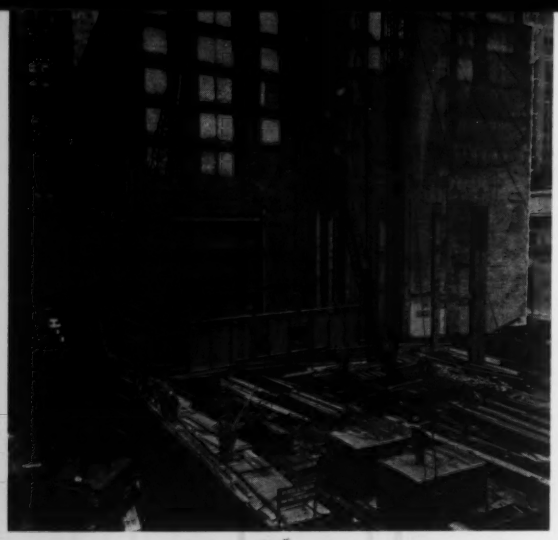
A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Pipe-Boom Tractors . . . Self-Propelled Scrapers and Bottom-Dumps . . . Tractor and Rubber-Tired Loaders . . . Diesel and Carbureted Engines



Steel Is Placed in Downtown New York Skyscraper

To avoid interference with traffic and crowds in congested financial district of downtown New York, girders for 27-story air-conditioned office building being erected by General Realty and Utilities Corp., at 20 Broad Street, are being placed weekends. Here 54-ft plate girder, weighing 39 tons and standing a full story high, is hoisted into position by Lehigh Structural Steel Co., which is erecting the framework under subcontract to the George A. Fuller Co. Eighteen such girders, ranging from 54 to 79 ft in length and from 39 to 57 tons in weight, will be used in all. Charles Mayer is the structural steel engineer.

N. G. Neare's COLUMN

R. ROBINSON ROWE, M. ASCE

"Well, Joe," encouraged the Professor, "I made the composite cookie-cutter problem easy for you by giving you your choice of three equations. Which one did you use?"

"They all had square roots," complained Joe Kerr, "and would get pretty complicated by the time you got to itty-bitty cookie H, so I helped my boy Hank do it with mud pies. We took 10 lb of hi-bond mud with a P.I. of 3.1416 and kneaded it out to make a flat circle, then cut out the 22 cookies according to your pattern. There was just a pound of the stuff left, so the waste was 10 percent."

"Why Joe!" exclaimed Professor Neare. "After I set up the problem so that all square roots would be integers, too!"

"And so that he wouldn't even have to use square roots at all," echoed Cal Klater. "Equation 3, relating curvatures e, f, g of a cluster of 3 circles to the curvature h of the circumscribing circle can be written more generally

$$h = e+f+g \pm 2\sqrt{ef+fg+ge} \quad \ldots(4)$$

to give both solutions to the problem of drawing a circle tangent to each of 3 circles which are tangent to each other in pairs, using the convention that a circumscribing circle has negative curvature. Calling these two solutions h_1 and h_2, if one is already known, the other is given by

$$h_2 = 2(e+f+g) - h_1 \quad \ldots(5)$$

"Now if we start with $a = -1$, $b = 2$, $b = 2$, the two solutions are the equal circles C, and

$$c = 2(-1+2+2) - c = 3$$

and the rest follow just as easily:

$$d = 2(-1+2+3) - 2 = 6$$
$$e = 2(-1+2+6) - 3 = 11$$
$$f = 2(-1+3+6) - 2 = 14$$
$$g = 2(2+2+3) - (-1) = 15$$
$$h = 2(2+3+6) - (-1) = 23$$

"Then with areas . . . ."

"Well I'll be an ape's aunt," muttered Joe.

". . . . proportional to squares of diameters," continued Cal, "and counting cookies of each size, the waste is

$$1 - \frac{2}{2^2} - \frac{2}{3^2} - \frac{4}{6^2} - \frac{4}{11^2} - \frac{4}{14^2} - \frac{2}{15^2} - \frac{4}{23^2} = 0.0967503."$$

"Which is so near Joe's 10% that Hank Kerr must know his mud π's," quipped the Professor.

"And I want another chance with those equations," begged Joe.

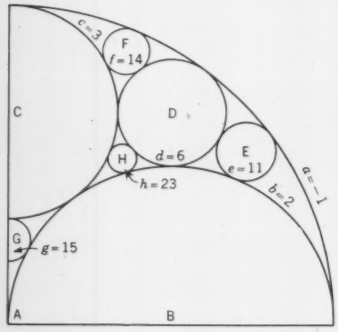


Fig. 1. Curvatures of cookies were all integers.

"All right," agreed the Professor, "help me make up another problem. Suppose first that 3 circles just fit in a large one without covering its center, then one more in each of the 3 lunes between the large circle and a pair of inner circles. Finally let's suppose the curvatures of all 7 circles are 7 different integers."

"I thot you asked me to help," complained Joe.

"You *can* help. You can decide whether to figure mud pies in a wash tub or pearls in a pill box."

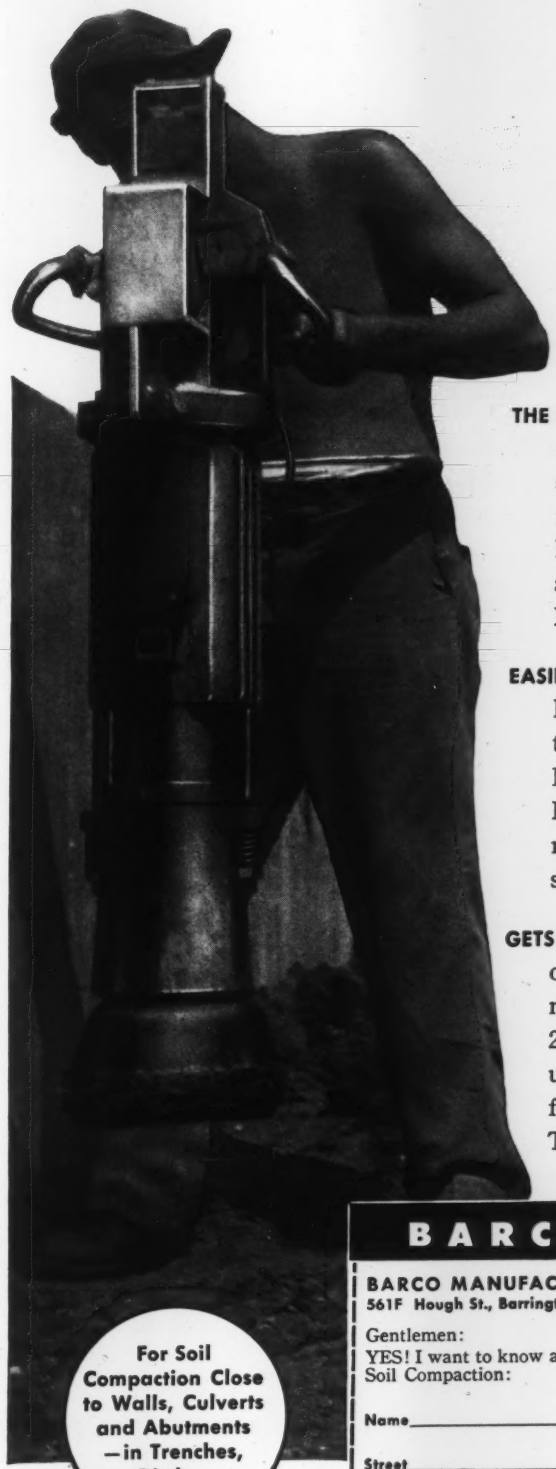
[*Cal Klaters were Richard Jenney, Flo Ridan (Charles G. Edson), Ad L. Pate (G. H. Wilsey), S. K. Rueball (Keith Jones), Tom J. Ogburn III, Thatchrite (Guy C. Thatcher), and Adolf Antshel, most of whom noted that in Equation 1 (April issue, page 86) the radical shouldn't cover the second half of the denominator.*]

Connecticut Begins Long Plate-Girder Span

Construction of a $10,539,754 bridge that will have the longest plate-girder span in the country has been started by the State of Connecticut. The bridge and its approaches, totaling 3,799 ft in length, will carry the Connecticut Turnpike over the Quinnipiac River. It is scheduled for completion in November 1957. The main 387-ft span will be flanked by two similar units on either side, each 258 ft long. It will be 40 ft longer than similar structures carrying the New Jersey Turnpike over the Hackensack and Passaic rivers.

The designer is D. B. Steinman, of New York, and the contractors are the William L. Moore Building Corp. and the Lopier Construction Co., also of New York. The Bethlehem Steel Co. will build the superstructure under a $7,887,754 contract.

WHEN CONSTRUCTION JOBS CALL FOR SOIL COMPACTION



BARCO is the ANSWER!

THE KEY TO BETTER CONSTRUCTION—No recent trend in construction has had a more phenomenal growth than the specification of HIGH DEGREE SOIL COMPACTION for all kinds of projects—Atomic Energy, Hydroelectric Power and Flood Control Dams, Highways, Toll Roads and Freeways, Airports, Bridges, Buildings, and Housing Developments!

EASILY MEETS RIGID SPECIFICATIONS—In test after test, Barco Rammers have demonstrated their ability to deliver 95% to 97.5% compaction (modified Proctor Method)—EASILY! EFFICIENTLY! ECONOMICALLY! The Barco Rammer is especially useful for compacting fill in restricted areas. ONLY the Barco Rammer can produce specified high degree compaction on lifts up to 20 inches.

GETS JOBS FINISHED ON TIME—One of the biggest advantages offered by Barco Rammers is ability to handle work in minimum time. On area tamping, one man can average 20 to 30 cubic yards of fill per hour. On trench backfill, using lifts up to 24", the rate for 18" trench is 360 to 600 feet per hour. *When time is at a premium,* BARCO IS THE ANSWER—find out about it NOW!

For Soil Compaction Close to Walls, Culverts and Abutments —in Trenches, Ditches

BARCO *GASOLINE* RAMMER

BARCO MANUFACTURING CO.
561F Hough St., Barrington, Illinois

Gentlemen:
YES! I want to know about Barco Rammers for Soil Compaction:

Name_____

Street_____

City_____

☐ Please send General Catalog No. 621.

Brown & Root, Inc., builds Peligre Dam in Haiti with Blaw-Knox Steel Forms

• The construction of the Peligre Dam project by Brown & Root, Inc., of Houston, is a typical example of the way Blaw-Knox Steel Forms and Blaw-Knox Engineers' Consultation Service can help solve difficult concreting problems. This buttress-type dam, which will span Haiti's biggest river, the central Artibonite, will be 1075 feet long and 225 feet high.

Among the problems which faced Brown & Root engineers was forming the overhang buttress section. To solve this problem, Blaw-Knox suggested a special type cantilever form.

Whether the construction project is a big dam, tunnel, bridge, retaining wall or sewer, Blaw-Knox engineers can help in the preliminary planning stage to solve difficult forming problems *before* the plans are on the drawing board.

BLAW-KNOX

BLAW-KNOX COMPANY

STEEL FORMS DEPARTMENT • BLAW-KNOX EQUIPMENT DIVISION

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WORKABLE, PLASTIC concrete mixes made with Atlas Duraplastic Cement helped speed construction of both structural and paving portions of Ohio State Highway, Beechmont Levee Project at Cincinnati, O. Contr.: Vest & Bartell, Cincinnati.

Why will this concrete last longer?

Both paving and structures are built to last longer . . . when they're made with Atlas Duraplastic* air-entraining portland cement. For Atlas Duraplastic cement gives concrete greater durability . . . fortifies it against freezing-thawing weather and scaling caused by de-icing salts.

Atlas Duraplastic cement also gives concrete mixes greater workability that aids proper placement . . . gives them more cohesiveness to resist segregation. Paving jobs finish easily, and in structural concrete, surface appearance is improved.

YET DURAPLASTIC COSTS NO MORE than regular cement — requires no unusual changes in procedure. Complies with ASTM and Federal Specifications. For descriptive booklet, write:

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UNITED STATES STEEL (USS) CORPORATION SUBSIDIARY

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*"DURAPLASTIC" is the registered trade-mark of the air-entraining portland cement manufactured by Universal Atlas Cement Company.

CE-D-178-C

AIR-ENTRAINING PORTLAND

Atlas® Duraplastic Cement

MAKES BETTER CONCRETE AT NO EXTRA COST

United States Steel Hour—Televised on alternate Wednesdays—See your local newspaper for time and station.

DECEASED

George Parker Bard (M. '09), age 91, of recent years associated with the Friden Calculating Machine Agency, Birmingham, Ala., died recently at his home in Birmingham. For many years Mr. Bard was employed by the Petroleum Iron Works of Youngstown, Ohio, as New York sales manager, sales manager, and president, handling 25 percent of the steel plate work required for the petroleum industry east of the Rocky Mountains. He was employed by the Biggs Boiler Works of Akron, Ohio, as New York district representative for eleven years. He was a graduate of Dartmouth College, class of 1889.

William H. Becker (A.M. '15), age 70, engineer with the William H. Becker Engineering Co. and owner of the Phoenix Blue Print Co., Phoenix, Ariz., died there recently. Early in his career Mr. Becker worked on the Big Creek Project at Fresno, Calif., as research engineer and in the same capacity for the City of San Francisco. Under the firm name of Holmquist & Becker and, later, the William H. Becker Engineering Co., Mr. Becker had engaged in general practice in Phoenix for the past 32 years.

Archibald Alexander Brown (A.M. '14), age 71, consulting engineer of Berkeley, Calif., died there recently. A graduate of New Mexico Agricultural College, class of 1906, Mr. Brown had been with the city engineer's office in San Francisco on design of new sewer and high-pressure water systems and with the Board of State Harbor Commissioners on San Francisco Harbor improvements. He was engineer for the California Sugar Refining Co., Berkeley, before entering private practice in 1921.

Carl Cobb Burkett (A.M. '27), age 61, city engineer of El Dorado, Ark., died at his home in Camden, Ark., recently. Mr. Burkett studied engineering at the University of Arkansas and had been with the Arkansas State Highway Department for many years as assistant district engineer and engineer at Little Rock. More recently he had been manager of the John T. Burkett Estate at Camden.

Henry Cash (M. '29), age 67, consulting engineer of Brooklyn, N.Y., died at his home there on January 10. Mr. Cash received a degree in civil engineering from Cooper Union and a law degree from Brooklyn Law School. He was a member of the Bureau of Buildings, Borough of Manhattan, from 1917 until 1943, first as engineering inspector and after 1930 as assistant engineer. Of recent years he had a consulting engineering practice in Brooklyn.

Franklin Edward Estes (M. '17), age 78, consultant and analyst of Pleasant Grove, Utah, died recently at a veterans hospital near Salt Lake City. Mr. Estes worked for various railroads in the United States, Mexico, and Cuba. After service in World War I in the Army Corps of Engineers, in which he attained the rank of lieutenant-colonel, he was consulting and supervising engineer at Shreveport, La., and in New Mexico. Later he was project engineer for the New Mexico Highway Department. He had been in private practice at Pleasant Grove since 1949. Mr. Estes was a graduate of Arkansas State Normal School.

Arthur Graham Glasgow (M. '00), age 91, partner in the firm of Humphreys & Glasgow, New York and London engineering consultants, died recently at his home in Palm Beach, Fla. A graduate of the Stevens Institute of Technology, class of 1885, Mr. Glasgow worked in various fields of engineering in Kansas City, Mo., Philadelphia, and New York for several years. He had been in the firm of Humphreys & Glasgow since 1892. For many years he represented the firm's interests abroad, residing in Westminster, England. While there he designed and executed carburetted-water gas works. He returned to the United States in 1949.

Guy Walter Harris (M. '13), age 78, retired chief engineer of the Atchison, Topeka and Sante Fe Railroad, Chicago, Ill., died recently at his home in Beverly Hills, Calif. A specialist in railroad construction and maintenance, Mr. Harris was with the A. T. & S. F. Railroad Co. from 1898 until his retirement in 1948. From 1912 to 1918 he was chief engineer of the coast lines with headquarters at Los Angeles, and from 1928 on he was chief engineer of the system with headquarters at Chicago.

Geary Kimbrell (M. '32), age 78, retired bridge and structural engineer for the City of Portland, Oreg., died at his home there on February 25. He was educated at the University of Oregon, and for many years served Umatilla County, Oregon, as county highway engineer and Pendleton as city engineer. From 1919 to 1932 Mr. Kimbrell was assistant bridge and highway engineer for Portland, and for 18 years bridge and structural engineer. He retired in 1950.

Frederick Thomas Llewellyn (M. '06), age 86, retired research engineer, U. S. Steel Corporation, New York City, died at his home in Baton Rouge, La., on February 19. A specialist in the application of steel to structures, Mr. Llewellyn was engineer for the Gillette Herzog Mfg. Co. for many years, working on steel structures throughout the South and Mexico. In 1906 he joined the Carnegie Steel Co. as resident engineer at New York and in 1917 joined U. S. Steel. He retired in 1939. Inventor and patentee of interlocking steel and concrete piling units, Mr. Llewellyn was in charge of standardization of steel for shipbuilding for the U. S. Shipping Board. He was the author of many publications on steel and materials in ship construction, and a past-president of the American Welding Society. He was a graduate of the University of London.

Curtis Adolph Mees (M. '08), age 78, consulting engineer specializing in the design and construction of hydroelectric dams and power plants, died March 6 in Atlanta, Ga. For many years Mr. Mees was design engineer for the Southern Power Company, Charlotte, N.C. (now the Duke Power Company). From 1916 to 1930 he was in private practice with his brother under the name of Mees & Mees. Later he was with the Corps of Engineers, San Francisco office, investigating the feasibility of a salt water barrier for San Francisco Bay; consulting engineer for the Georgia Public Service Commission; and engineering and valuation consultant for the Georgia Power Company. Mr. Mees was the author of many articles on dams and hydroelectric systems. He was a graduate of Rose Polytechnic Institute.

Curtis A. Mees

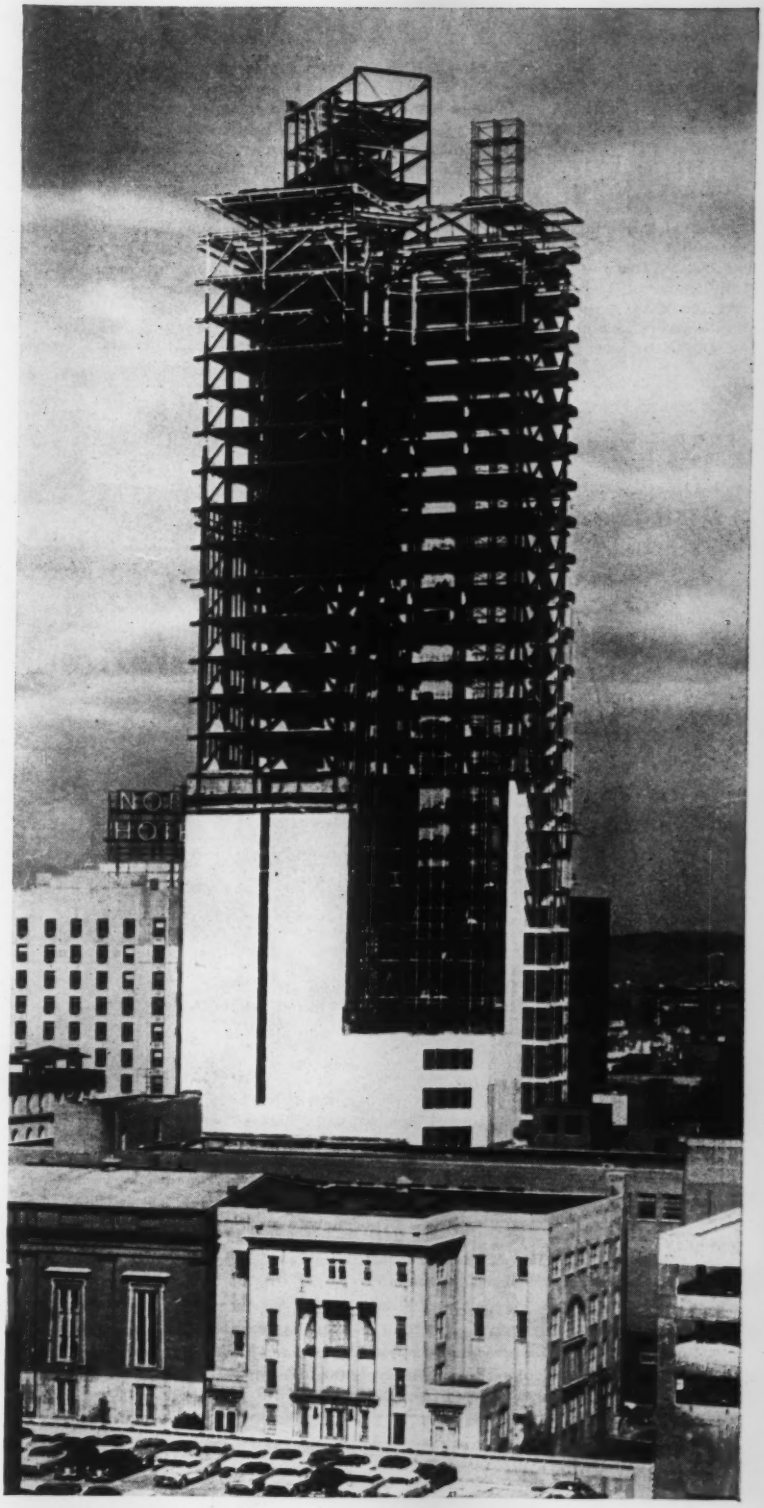
Jose Garcia-Montes (M. '36), age 63, Director of Industry, Cuban Ministry of Agriculture, for the past 19 years, died suddenly at his home in Havana in February. Prominent in the engineering development of his country, Mr. Garcia-Montes was chief designing engineer for many important projects there, including the Havana Water Works extensions. He served as Secretary of Agriculture from 1938 to 1939 and was in charge of a $4,000,000 irrigation plan of the Cuban government. He was president of the Cuban Society of Engineers from 1940 to 1942, and author of many publications outlining irrigation policies adopted by the Cuban government.

Robert M. Peabody (M. '44), age 75, formerly chief electrical engineer with the Metropolitan Water District of Southern California, died suddenly on March 17 while on a private inspection tour of the Colorado River Aqueduct at Gene Camp, Calif. Mr. Peabody joined the District in 1933 and served 17 years as first assistant to the chief electrical engineer, and in 1950 was promoted to the position of chief electrical engineer, from which he retired in 1951. He played an important part in the design of the pumping plants and participated in the original experiments

R. M. Peabody

(*Continued on page 94*)

Newcomer to Nashville



Tall and slender stands the steel skeleton for the Life & Casualty Building, shown at right shortly after topping out by Bethlehem crews. Heralded as the Southeast's tallest building, the 30-story skyscraper is the new queen of the Nashville skyline.

Exterior walls will consist of gleaming metal and glass set off by masonry trim at the corners, and dramatized by a massive metal fin extending the entire 409-ft height of the building. Other features include electronically controlled high-speed elevators, a year-round air-conditioning system, and cellular steel floors. Life & Casualty Insurance Company of Tennessee, the owners, plan to use the building as their home office, leasing excess space to tenants.

The approximately 3350 tons of steel required for the job were fabricated and erected by Bethlehem, using high-strength structural bolts (in accordance with ASTM Spec. A-325) for all stressed field connections.

Architect: Edwin A. Keeble Associates, Inc.
Structural Engineer: Ross H. Bryan
General Contractor: J. A. Jones Construction Co.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Deceased

(*Continued from page 92*)

and design work, conducted at the California Institute of Technology, on which the plants were built. A graduate of Harvard College, class of 1904, Mr. Peabody was with the U. S. Bureau of Reclamation from 1906 to 1915 and served during World War I as Captain in the Corps of Engineers. From 1920 to 1930 he was mechanical designing engineer with the Southern California Edison Co., at Los Angeles. As senior engineer with the U. S. Bureau of Reclamation at Denver in 1932 and 1933, he prepared specifications and designs of turbine installations for the Boulder Dam power plant.

J. P. H. Perry, Former ASCE Director, Dies

John Prince Hazen Perry (M. '18), age 74, prominent civil and construction engineer of New York City and a former Director of ASCE, died on April 14. With the Turner Construction Company from 1906 to 1950, Mr. Perry had been general manager of the organization's Chicago office and director and vice-president, with headquarters in New York. In 1951 he became head of the construction and facilities division of the recently created Munitions Board, and later was deputy for installations in the Office of the Assistant Secretary for Air. Following his return to private life, he served as president and director of the Lift Slab Corporation, until the end of 1955. At the time of his death he was consultant to Seelye, Stevenson, Value & Knecht, consulting engineers of New York. In addition to serving as Director of ASCE from 1933 to 1935, Mr. Perry had been president of the Metropolitan Section. He was also president of United Engineering Trustees and the Engineers Council for Professional Development. He was a graduate of Harvard College and author of many articles on construction subjects for CIVIL ENGINEERING and other publications.

J. P. H. Perry

PATIENT: 36 miles of twin 20" Cast Iron supply lines, Portsmouth, Virginia.

SYMPTOMS: Insufficient water in Portsmouth.

DIAGNOSIS: Low pipeline capacity caused by flow restricting tuberculation.

TREATMENT: The twin 20" mains were cleaned and cement lined in place without interruption of water supply service to Portsmouth. The Centriline Process of centrifugally applying cement mortar was used.

RESULTS: Each pipeline is now capable of permanently carrying twice as much water as prior to cleaning and lining.

Examine your own capacity, corrosion and leakage problems to determine the value of the Centriline treatment to you. Cleaning and cement lining in place has been the successful remedy for almost 1,000 miles of water supply pipelines.

CENTRILINE CORPORATION

A subsidiary of the Raymond Concrete Pile Company

140 CEDAR STREET, NEW YORK 6, N.Y.
WOrth 2-1429

Branch Offices in Principal Cities of the United States, Canada, and Latin America.

Norman K. Sheppard (A.M. '22), age 66, plant maintenance engineer for the Dow Chemical Co., Midland, Mich., died recently at his home there. Mr. Sheppard was a graduate of the University of Michigan, class of 1913. For many years he had been assistant structural engineer with the Detroit Department of Buildings, City of Detroit, and with Albert Kahn, Inc., of that city. In 1933 he joined the Dow Chemical Co., as designing engineer at Midland, and later became plant maintenance engineer in charge of scheduling and inspection of contract construction work there.

Mary Olga Soroka (A.M. '36), age 52, for the past eight years hydraulic engineer with the Corps of Engineers, Washington, D.C., died in a New York City hospital on April 6. Miss Soroka graduated from Massachusetts Institute of Technology in 1926. She had been engineer on hydraulic design and research for hydroelectric projects with the Stone Webster Engineering Corporation; engineer on air conditioning design and research with the Potomac Electric Power Company; and chief engineer on air conditioning for the Air Devices Corporation. In 1940 she was assistant engineer in the U. S. Engineer Office at New York City, and from 1942 to 1947 associate engineer in Washington. Miss Soroka was one of the first women engineers admitted to ASCE, which she joined as a Junior Member in 1927.

Henry G. Throop (M. '24), age 75, who retired in 1954 as construction engineer for the Carrier Corp., Syracuse, N.Y., died at his home there on January 18. He was a graduate of Cornell University, class of 1905. From 1906 to 1920 Mr. Throop was engineer of ways and structures for the Oneida Construction Company (now New York State Railways) at Utica and Syra-

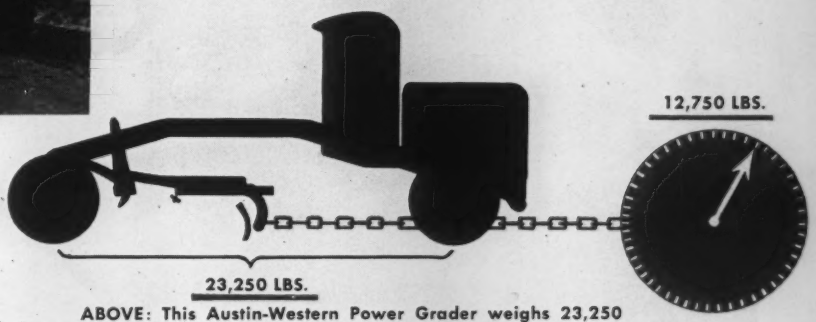
(*Continued on page 100*)

Not "How Big?" But "How Good?"

The ability of any motor grader to do hard cutting, and move big blade loads of material in the lower gears, where heavy work is done, depends entirely upon the amount of weight carried on *driving wheels.* Total weight has nothing to do with it.

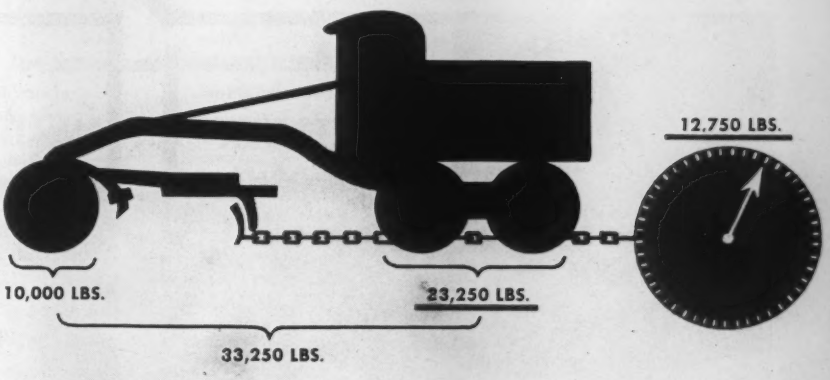
Most for Your Money

From every standpoint . . . first cost, operating cost and upkeep . . . the A-W Power Grader gives you more for your money . . . moves 30 percent more material than an ordinary grader of equal weight and horsepower; and as much material as heavier, more expensive graders . . . as explained in the diagrams at the right.



ABOVE: This Austin-Western Power Grader weighs 23,250 lbs.—all carried on driving wheels. Working in average dirt, it has a blade pull of 12,750 lbs.

BELOW: To obtain the same blade pull, an ordinary motor grader would have to carry 23,250 lbs. on its *rear drivers;* PLUS about 10,000 lbs. on its *dead front end,* for a total of 33,250 lbs.



SIZE IS NOT THE MEASURE OF MOTOR GRADER PERFORMANCE

There's more to the story. All-Wheel Steer . . . another exclusive Austin-Western feature . . . makes the machine twice as maneuverable as graders with front steer only; while the Controlled Traction made possible by the teamwork of All-Wheel Drive and All-Wheel Steer moves more material . . . moves it farther . . . moves it faster. Your nearby Austin-Western distributor will be glad to tell you the whole story of "The Power Graders That Have Everything."

Austin-Western

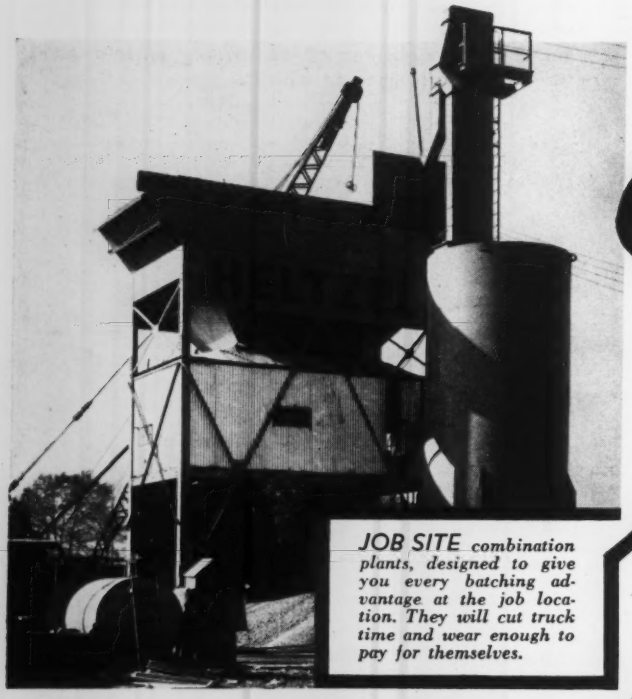
Power Graders · Motor Sweepers
Road Rollers · Hydraulic Cranes

Construction Equipment Division

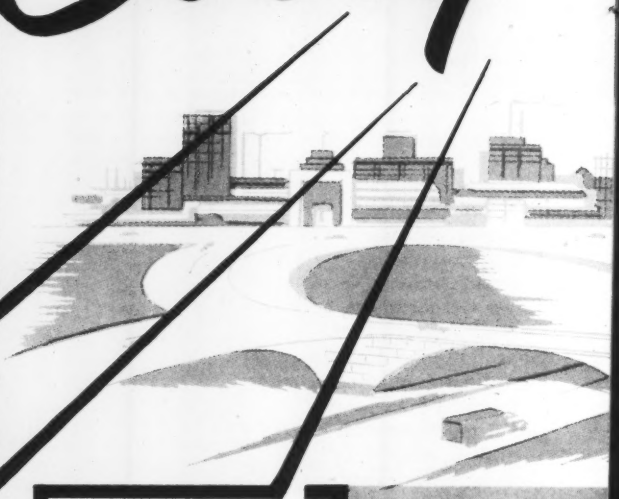
Manufactured by
AUSTIN-WESTERN WORKS
CONSTRUCTION EQUIPMENT DIVISION
Baldwin-Lima-Hamilton Corporation
AURORA, ILLINOIS

Heltzel Portable Batchmaster

Every



JOB SITE *combination plants, designed to give you every batching advantage at the job location. They will cut truck time and wear enough to pay for themselves.*



READY-MIX *plants ideal for decentralization —spotting at new housing developments, etc.*

PIPE OR BLOCK *plants for job size concrete products manufacture; new business or auxiliary production.*

Plants for... *Purpose*

***PAVING** plants — both aggregate and cement —that have proved themselves to be the finest yet engineered. True portability, plus unmatched speed and accuracy.*

HELTZEL PORTABLE BATCHMASTERS ARE SETTING PRODUCTION, ECONOMY RECORDS WHEREVER CONCRETE IS BATCHED

● Heltzel designs and builds the most complete line of portable plants in the industry. There's a plant of every size for every type batching. From the small 30 ton Highway Plant to the big 200 ton Paving Plants—for straight cement, straight aggregate or combinations—every Heltzel Batchmaster Portable is designed to go up fast and dismantle easily, with a minimum crew. They are sectionalized to be carried over the roads on standard carry-all equipment.

Don't buy any plant until you have talked with the owner of one of these new Batchmasters, for true portability is but one of many new features that make the Heltzel 1956 Line the fastest, most accurate and flexible plants on the market. And remember Batchmasters cost no more—so why not operate with the finest.

HELTZEL

BATCHING PLANTS

THE HELTZEL STEEL FORM AND IRON COMPANY
81000 THOMAS ROAD WARREN, OHIO

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Monotube Foundation Piles...

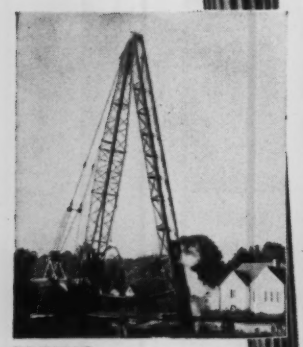
BEST START

for saving time — money — materials

IN today's highly competitive construction business, it's mighty important to invest time, money and materials as wisely as possible. That's why you'll want to learn more about *the best start* when building . . . tapered, fluted steel Monotube foundation piles.

Illustrated on this page are several examples of field work involving Monotube piles. With a fast, single girt weld of telescopic joints, Monotubes can be extended to any required length. Cut-offs are easy too . . . and no waste, as these same cut-offs can be re-used to extend other piles. Light-weight construction plus cold-rolled strength means easier handling and faster pile installation. Tubular design makes inspection before concreting quick and sure.

Mentioned above are only a few of the reasons why more and more foundation jobs are getting off to a good start using Monotube piles. To get *all* the facts, write The Union Metal Manufacturing Company, Canton 5, Ohio. Request Catalog No. 81.



DRIVING

EXTENDING

CUTTING OFF

INSPECTION

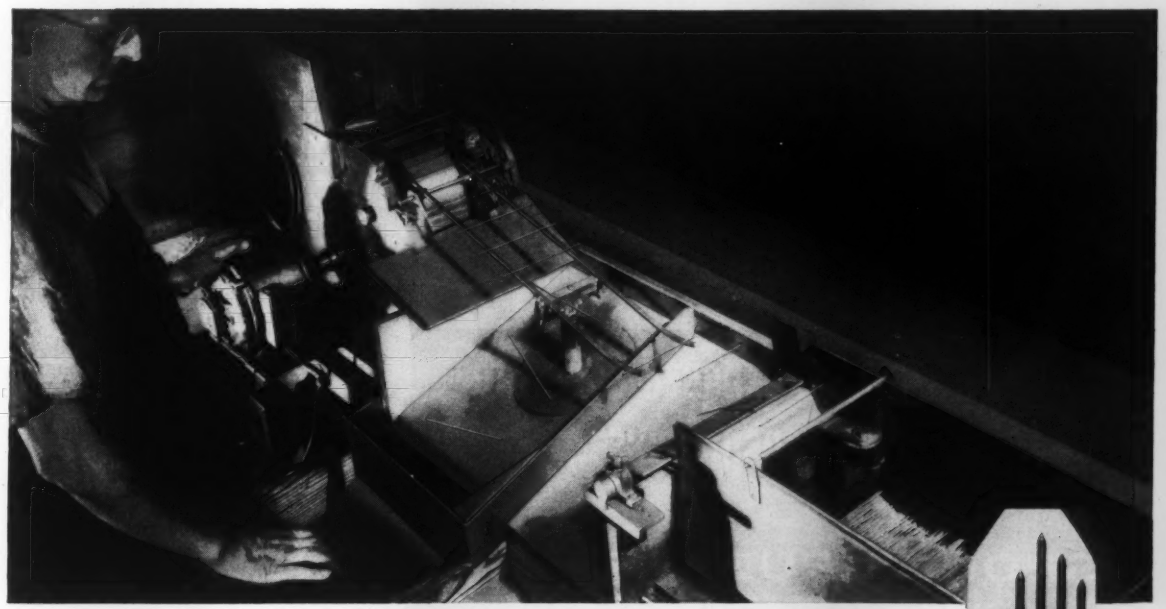
1906 *Fiftieth Anniversary* 1956

UNION METAL

Monotube Foundation Piles

We put Turquoise leads over the jumps

SO THEY WON'T BIND IN YOUR HOLDER!



To assure you of perfectly straight, symmetrical Turquoise Drawing Leads, we send them down this "ski jump" in the Eagle Pencil plant.

The slightest unevenness in a lead makes it wobble and careen off the end of the jump into the "reject chamber". Only the true, perfectly formed leads clear the gap, and land in your holder.

Turquoise leads are of "*Electronic" graphite – reduced to micronic size. Millions more of these finer graphite particles are compacted in every inch of lead. That's why Turquoise deposits a denser, blacker line that reproduces to perfection . . . gives you the strongest, smoothest, longest-wearing point that ever met paper. 17 degrees, 6B to 9H.

*TURQUOISE

DRAWING PENCILS, LEADS AND HOLDERS

HEADQUARTERS FOR QUALITY PENCILS
100 YEARS
EAGLE PENCIL COMPANY
1856 - 1956

NEW LEAD HOLDER! Eagle's *new* 3379 Turquoise Lead Holder is precision-made for trouble-free operation. The *Prestomatic* button releases the lead—and a spring relocks the rifled jaws to hold the lead firmly in place. Red, yellow, and green release buttons identify the degree of lead contained.

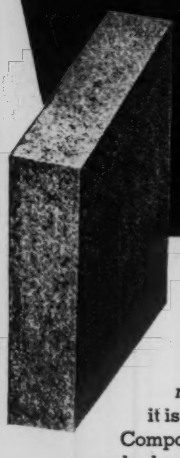
EAGLE PENCIL COMPANY NEW YORK • LONDON • TORONTO • MEXICO • SYDNEY

When Concrete joints must be kept filled

Specify and Use

SERVICISED

SELF-EXPANDING CORK



1. **Expands as much as 50% beyond original thickness after compression**
2. **Non-extruding**
3. **Resilient**

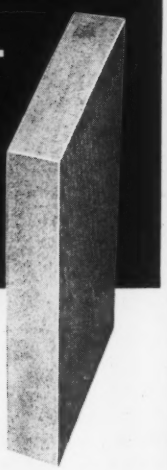
Servicised Self-Expanding Cork Joint provides *maximum joint filling* regardless of concrete movement because it is specially treated to expand to 150% of original thickness. Composed of granulated cork and synthetic resin binder molded under heat and pressure. Widely used in tunnels, outlet works, spillways, stilling basins, sewage treatment works and water filtration works.

When joints in exposed concrete must be inconspicuous...

Specify and use Servicised

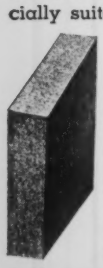
SPONGE-RUBBER

CEMENTONE®



1. **Blends with color of concrete**
2. **Fully resilient**
3. **Non-extruding**

Servicised Sponge Rubber Cementone Joint is composed of high quality blown sponge rubber of uniform thickness and density. Gray in color, it blends with concrete to provide a fully resilient, inconspicuous joint filler. Especially suitable for bridges, viaducts, pre-cast concrete wall panels.



SERVICISED STANDARD CORK EXPANSION JOINT

Similar in composition to Self-Expanding Cork, Standard Cork Joint has a very high recovery rate after compression —95%. It is light in color and will not extrude under compression.

Write for the Servicised Catalog. It has complete details on Servicised Premolded Joint Fillers.

SERVICISED PRODUCTS CORPORATION

6051 WEST 65th STREET • CHICAGO 38, ILLINOIS

Deceased

(*Continued from page 94*)

cuse. He was superintendent of the C. D. Murray Co., Inc., Syracuse, for 14 years until joining the Carrier Corp. in 1943.

Robert Lyle Totten (M. '16), age 71, of recent years project engineer with the International Cooperation Administration, Washington, D.C., died there on January 29. Early in his career Mr. Totten held various positions with railroads in the South, and from 1909 to 1935 under the firm name of Robert L. Totten, Inc., acted as local engineer in charge of design and building the Birmingham, Ensley and Bessemer Railroad at Birmingham, Ala. Later, under the firm name Totten & Loving, he was in consulting practice in Atlanta, Ga. Mr. Totten served in the Army Corps of Engineers during World War II and in the Executive Office of the President. He studied at the University of Kentucky.

Clement Isaac Walker (M. '04), age 95, prominent engineer in subway construction and retired general superintendent of the Empire City Subway Co., Ltd., New York City, died recently at his home at La Crescenta, Calif. Early in his career Mr. Walker worked on various railroads. From 1893 to 1909 he was chief engineer for the Union Subway Construction Co., engaged on subway construction in the United States, South America, and Australia. Mr. Walker had been with the Empire Subway Co., Ltd., for over 21 years, retiring in 1930.

Herbert H. Wessel (A.M. '45), age 52, engineer of plans for the Arizona State Highway Department, died at Phoenix, Ariz., on March 1. Mr. Wessel, a graduate of Purdue University, became associated with the Arizona State Highway Department in 1930 as a draftsman and designer. In 1948, he was made engineer of plans. He was instrumental in building a network of modern state highways and recently received a Meritorious Service Certificate from the American Association of State Highway Officials.

Charles P. Williams (A.M. '01), age 90, retired consulting engineer, died at his home in San Diego recently. A graduate of Missouri State University, Mr. Williams was a specialist in the field of hydraulics and irrigation drainage. From 1906 to 1926 he was with the U. S. Reclamation Service (now the Bureau of Reclamation) as engineer, project manager, acting supervising engineer, and assistant chief engineer of the northern division. He went into private practice in 1926, serving also as consulting engineer for the Bureau on flood control, irrigation, and drainage projects in the lower Rio Grande Valley, Texas.

BIG NEWS in road maintenance:

COLD APPLIED

BITUMULS®

Slurry Seal

Spreader-box application of Bitumuls Slurry is fast and easy.

BITUMULS SLURRY SEAL is a fast, simple, and highly effective technique for getting extra years of satisfactory service out of cracked, worn, or spalled pavements.

The slurry, itself, consists of a mixture of Bitumuls emulsified asphalt and water to which sand or crusher dust (or a combination of both) is added to form a free flowing mix.

Typical Slurry Preparation

On a typical successful operation, the Bitumuls emulsion and water were first fed into the drum of a transit mix truck. Then aggregate, conforming to the following gradation, was added slowly to assure complete coating:

Sieve Sizes	*Per cent Passing*
Number 20	100
" 30	91
" 50	54
" 100	20
" 200	5

Method Of Application

The slurry, delivered to the job in the transit mixer, was chuted into a spreader box, towed behind the mixer truck, onto the pre-watered pavement. (The spreader box was a rectangular, sled-like frame, one traffic lane in width. It was equipped with a rubber strike off, or squeegee blade, which assured even distribution and uniform coating, and forced the slurry into cracks and depressions.)

Pioneered In The West

Quickly and easily applied at exceptionally low costs, Bitumuls slurry sets rapidly and can usually be opened to traffic within two to three hours.

This method was pioneered by Los Angeles County forces. Working closely with them were Engineers of American Bitumuls & Asphalt Company.

Bitumuls Slurry Seal has been used effectively in both Southern and Northern California, and test sections have been placed in other areas of the country. The "big news" of this relatively new method of extending pavement surface life is spreading fast. Get full data from our nearest office.

Aggregate and Bitumuls are fed into transit mix truck, then water is added as required.

Close-up view of the specially-designed spreader-box.

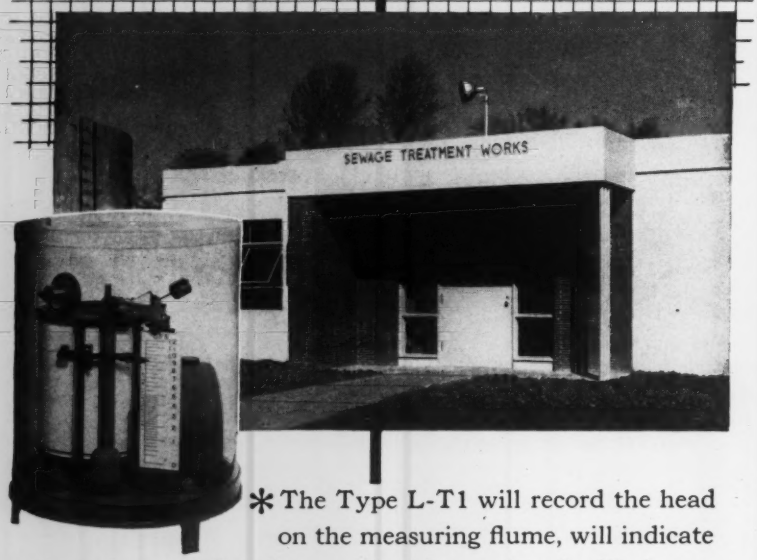
Leading Marketers of Asphalts, Cutbacks, and Emulsions — Nationwide.

American Bitumuls & Asphalt Company

200 BUSH STREET, SAN FRANCISCO 20, CALIFORNIA • Perth Amboy, N. J. • Baltimore 3, Md.
Cincinnati 38, Ohio • Columbus 15, Ohio • Mobile, Ala. • Tucson, Ariz • Seattle, Wash.
Baton Rouge 2, La. • St. Louis 17, Mo. • Inglewood, Calif. • Oakland 1, Calif.
Portland 7, Ore. • Washington 5, D.C. • San Juan 23, P. R.

PROBLEM:
To obtain at minimum cost the essential information on flow required for efficient operation of a small sewage treatment plant.

SOLUTION:
Stevens Type L-T1 Recorder*



* The Type L-T1 will record the head on the measuring flume, will indicate the volume of flow for any time interval and will give an instantaneous reading of the rate of flow. The head record, made on convenient rectangular coordinates, is basic information for permanent record from which plant operators and State Sanitary Engineers can check flows and volumes. The volume reading from the totalizer dials and the rate of flow indicator are essential for intelligent operation. Readings can be made in any desired volume and flow units.

STEVENS DATA BOOK

...invaluable for your reference file
144 pages of technical data on recorder installations... plus a wealth of hydraulic tables and conversion tables. **Send $1.00 (No C.O.D.'s)**

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LEUPOLD & STEVENS INSTRUMENTS, INC.
4445 N. E. GLISAN STREET • PORTLAND 13, OREGON
Foremost in Precision Hydraulic Instruments Since 1907

New in Education

University of Missouri Centennial. The University of Missouri College of Engineering is celebrating its centennial anniversary this spring. A special bulletin, "One Hundred Years Ago," gives a brief history of the teaching of engineering there during the past century.

Caltech Tour. Nineteen graduate students of civil engineering at the California Institute of Technology have just returned from an extensive tour of the irrigation, flood control, and water power facilities of the lower Colorado River basin. Started by the late Prof. Franklin Thomas, Past-President ASCE, the tours have been an annual feature of the civil engineering program at Caltech.

New Buildings. One of the first groups of buildings to be constructed by Colorado A & M College under a new program recently authorized by the Legislature will be the School of Engineering. Construction of the new center is expected to start this spring and to be finished by the fall of 1957. . . . Ground was broken in March for the third building at the Association of American Railroads' research center on the Illinois Institute of Technology campus in Chicago. The $500,000 building, latest structure in a long-range program to provide complete research facilities for the railroad industry, will be used primarily for rail, track, ballast, detector car, and structural research. . . . New York University announces a gift of $2,000,000 from Frank Jay Gould, American financier and alumnus of the university, toward completion of its engineering and science center at the University Heights campus in the Bronx. The gift represents half the cost of the structure.

Research. An educational experiment at Rensselaer Polytechnic Institute indicates that colleges of science and engineering could successfully advance some students to graduate study without benefit of the senior year. This finding, highly important in light of the urgent need for scientists and engineers, came out of a six-week experimental program conducted at the college last summer.

New Courses. Demands in the field of applied geology have resulted in the organization of an integrated undergraduate curriculum in Engineering Geology at the Colorado School of Mines. Lower Division courses are common to all curricula offered by the school. Upper Division courses include fundamental courses in geology and more specialized courses in civil engineering. Prerequisites for the two-year course and other details are available from Lawrence Ogden, Instructor in Geology, Colorado School of Mines, Golden, Colo. . . . A three-year research and training program in water-resources development is being launched

(*Continued on page 106*)

Set your sights on an HD-6G

for top performance
for top dependability
for top versatility

1½ yd bucket **55 belt hp** **19,600 lb**

and all these exclusive on-the-job advantages important to both owners and operators . . .

Allis-Chalmers long-life diesel engine — power that handles tractor and bucket demands with ease.

Heavy welded-steel shovel side frames and low stabilizer — provide greater strength, low center of gravity, outstanding visibility.

Full-flow filtering — filters oil three ways, provides long-life protection for hydraulic system.

Six truck-wheel stability — almost 7 ft of track on the ground for superior balance.

1½-yd two-position bucket — handles big loads efficiently in loose material or hard-packed dirt.

All-steel, box-A main frame — soaks up shock loads, protects the entire power train.

One-piece steering clutch and final drive housing — line-bored for true alignment of shafts and gears.

Straddle-mounted final drives— with bearings on both sides of gears to maintain correct gear tooth alignment.

Simplified lubrication (including 1,000-hour lubrication intervals on truck wheels, idlers and support rollers) provides extra working time.

Unit construction —makes service easier, faster. Major units can be removed without disturbing adjacent assemblies.

Plus husky wrap-around radiator guard . . . simplified piping . . . heavy-duty truck frames . . . heavy-duty, roller-bearing truck wheels . . . matchless control . . . and the convenience of 24-volt direct electric starting.

Check the complete service program offered by your Allis-Chalmers construction machinery dealer. His factory-trained servicemen, factory-approved facilities, and stocks of True Original Parts keep your equipment operating properly . . . provide the kind of service that saves you money. See him soon; he'll be glad to show you an HD-6G at work.

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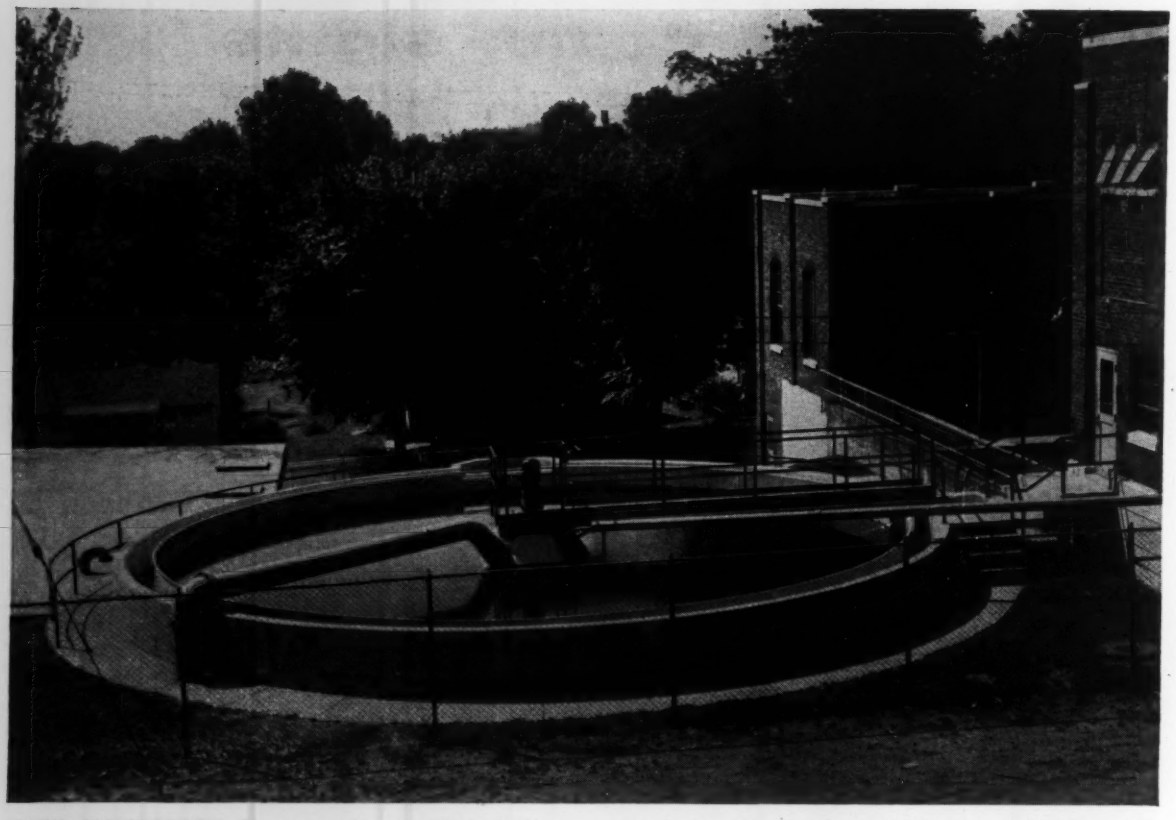

RAPID CLARIFICATION: Storms can increase Wabash River turbidity from 50 to 1500 ppm in as little as six hours! No matter how much or how fast turbidity changes, this Permutit Precipitator cuts it to less than 5 ppm in one fast step!

Clear water for Mount Carmel despite rapid turbidity jumps of 50 to 1500 ppm in 6 hours!

GROWTH OF POPULATION and increasing settling-basin odors from sewage and oil-field wastes persuaded Mount Carmel officials to look for a more efficient water-treatment plant. The new plant would have to deliver twice as much water . . . eliminate bad odors . . . handle spurts of *high* turbidity.

HOW IT'S DONE: A suspended sludge-blanket type of equipment was indicated, and a Permutit Precipitator was installed. Now they get 2½ mgpd of clear water *in half the time* it took two old settling basins to treat only 1½ mgpd! All with *no increase in manpower.* There are no more bad odors during treatment. Chemical costs are lower.

FILTER SAVINGS: Added to the existing three filters . . . two new filters with Permutit Monocrete® Underdrain Systems that are non-corrodible, low in cost, easily built.

AUTOMATIC FEATURES: Mount Carmel's Precipitator has photoelectronic control. The unit is automatically blown down in direct proportion to the flow rate and the amount of total solids precipitated. Since the three existing filters had obsolete controls, five new gravity filter operating tables were installed to control backwashing and filtering automatically!

"Everything is running smoothly. We're getting a better grade of water . . . clearer water," reports Supt. Elmo Conrady.

"It's all automatic. Mud goes right back into the river . . . eliminating the cleaning of basins," reports Chief Operator Cedric Seaton.

"It has given excellent performance since operation began," report Warren & Van Praag, Inc., Consulting Engineers, Decatur, Illinois.

PERMUTIT WILL WORK WITH YOU to modernize your present plant or to plan a new one. Call us early in planning so we can be of most help. The Permutit Company, Dept. C-5, 330 West 42nd Street, New York 36, N. Y.

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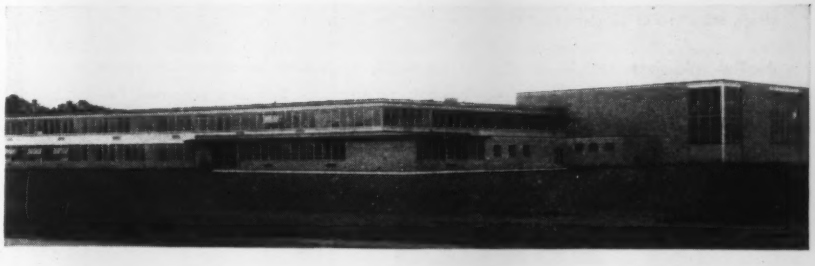
Prefabricated by electronic controlled welding equipment, these strong lightweight steel joists are easy to handle and place, and are adaptable to a wide range of construction requirements.



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Piers for 15th Street Bridge, Allentown, Pa.
E. A. Daylor Company, contractors.

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for round columns of concrete

The round concrete piers for this Allentown, Pa. bridge were formed by SONOTUBE Fibre Forms. These piers are 28-feet high and 36-inches in diameter.

Low-cost SONOTUBE Fibre Forms erect quickly because they handle easily and require minimum bracing. Use SONOTUBES for round concrete piers, columns and underpinning and save time, money and labor! Also an economical form for encasement of steel columns and steel and wooden piles.

Available in sizes from 2" to 36" I.D. up to 50' long. Can be ordered in specified lengths or sawed to your requirements on the job. Sonoco's patented "A-Coated" SONOTUBES are for finished columns; wax-coated also available. Order SONOTUBES for your next job!

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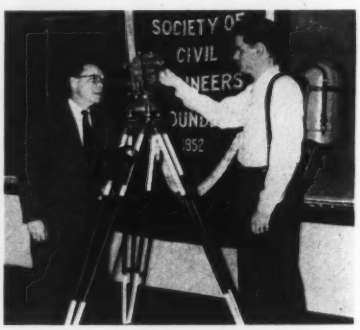
New in Education

(*Continued from page 102*)

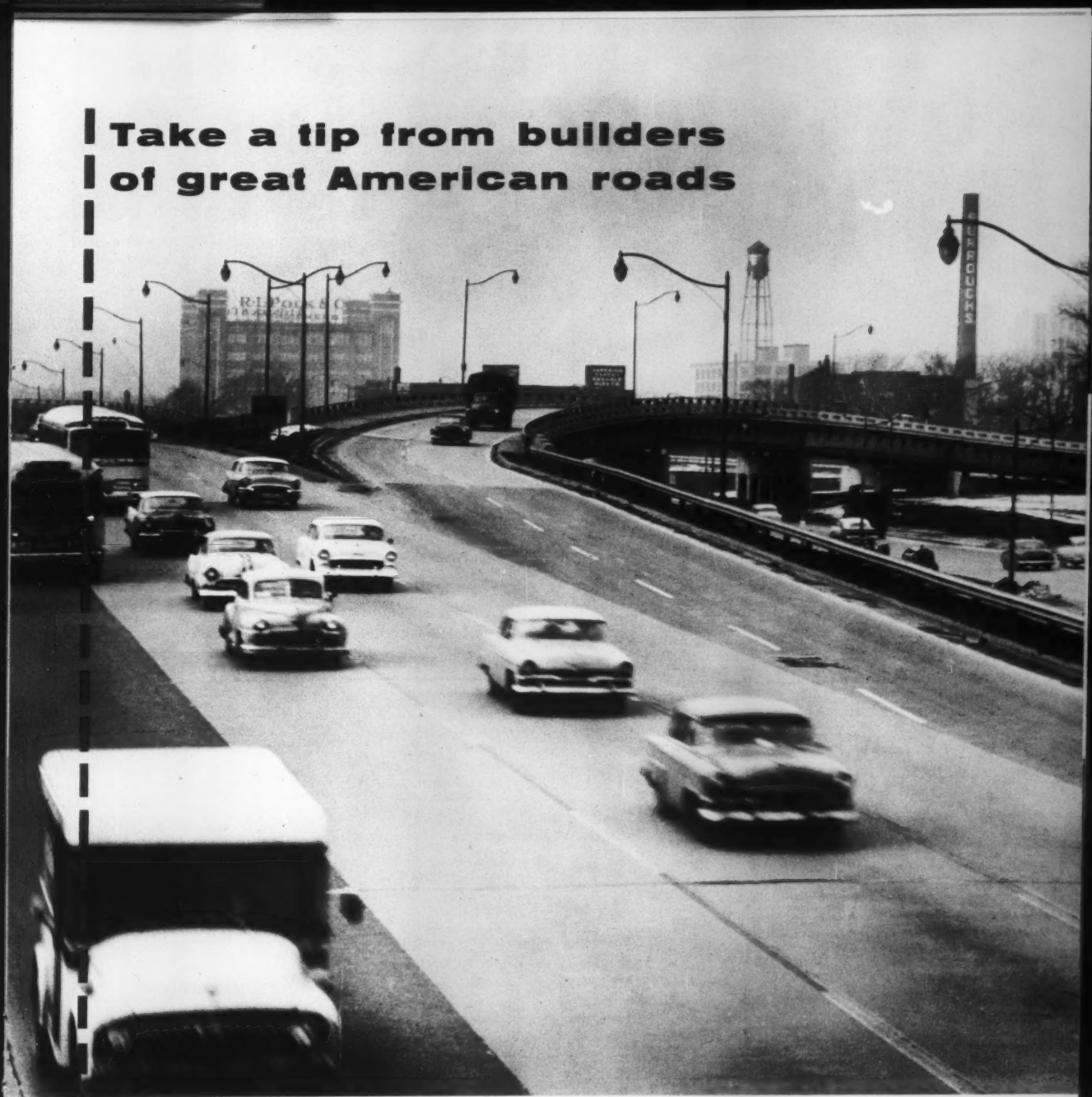
at the Harvard Graduate School of Public Administration. It is primarily designed to test new tools of analysis—economic, engineering, governmental—in planning development of the nation's river basins. . . . A two-week Special Summer Program on the problems of instability in laminar flow and turbulence will be given at Massachusetts Institute of Technology, July 16–27. Dr. Chia-Chiao Lin, professor of mathematics at M.I.T., will direct the program. M.I.T. will also have a two-week Special Summer Program in Disposal of Industrial Wastes by Biochemical Processes, August 20–31. Dr. Rolf Eliassen, M. ASCE, professor of sanitary engineering and director of the Sedgwick Laboratories of Sanitary Science at M.I.T., will head the program. Details and application blanks from the Summer Session Office, Room 7-103, Massachusetts Institute of Technology, Cambridge 39, Mass. . . . As a contribution to the recruitment and training of technical writers, Tufts University, Medford, Mass., in cooperation with the Society of Technical Writers, is offering the first of an annual series of Summer Workshops in Technical Writing. The dates are July 2 through 27. The course will give practice in preparing and editing proposals, reports, instruction books, technical manuals, and brochures. Send inquiries to the Director of the Summer School, Tufts University, Medford, Mass. . . . The University of Florida College of Engineering announces a new Ph.D program in sanitary engineering. Graduate assistantships in research are available annually for a number of students (stipends $133 to $177). Appointments as assistants in research, with the equivalant rank of instructor, are available with stipends above those for graduate assistants. For further information write to the Dean, Graduate School, University of Florida, Gainesville, Fla.

Theodolite for Rensselaer. The Rensselaer Polytechnic Institute Department of Civil Engineering is proud possessor of



the theodolite used for the control work on the new $60-million-dollar Tappan Zee Bridge on the New York Thruway. It is the gift of Madigan & Hyland, of New York City, designers and consultants on the project.

Take a tip from builders of great American roads



Edsel Ford Expressway, *important new traffic artery in Detroit, Michigan, is reinforced with American Welded Wire Fabric.*

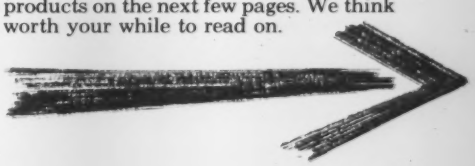
Take a tip from the Pennsylvania Turnpike Commission. the Ohio Turnpike Commission, the Indiana State Highway Department, and others who are lacing America together with a network of outstandingly fine superhighways and thruways. Take a tip from them and use quality construction materials manufactured by American Steel & Wire to increase the life, the comfort, and the safety of your new roads.

Make your Portland Cement concrete slabs 30% stronger, at extremely low cost, with American Welded Wire Fabric. You will find it easy to handle . . . readily available in any size and style you need (greatly expanded manufacturing facilities assure this).

Use longer concrete slabs for smooth riding, to reduce installation costs and speed construction. Use American Road Joints to provide proper load transfer for a balanced pavement design.

Help prevent off-road crashes with Multisafty Cable Highway Guard and American Beam-type Highway Guard.

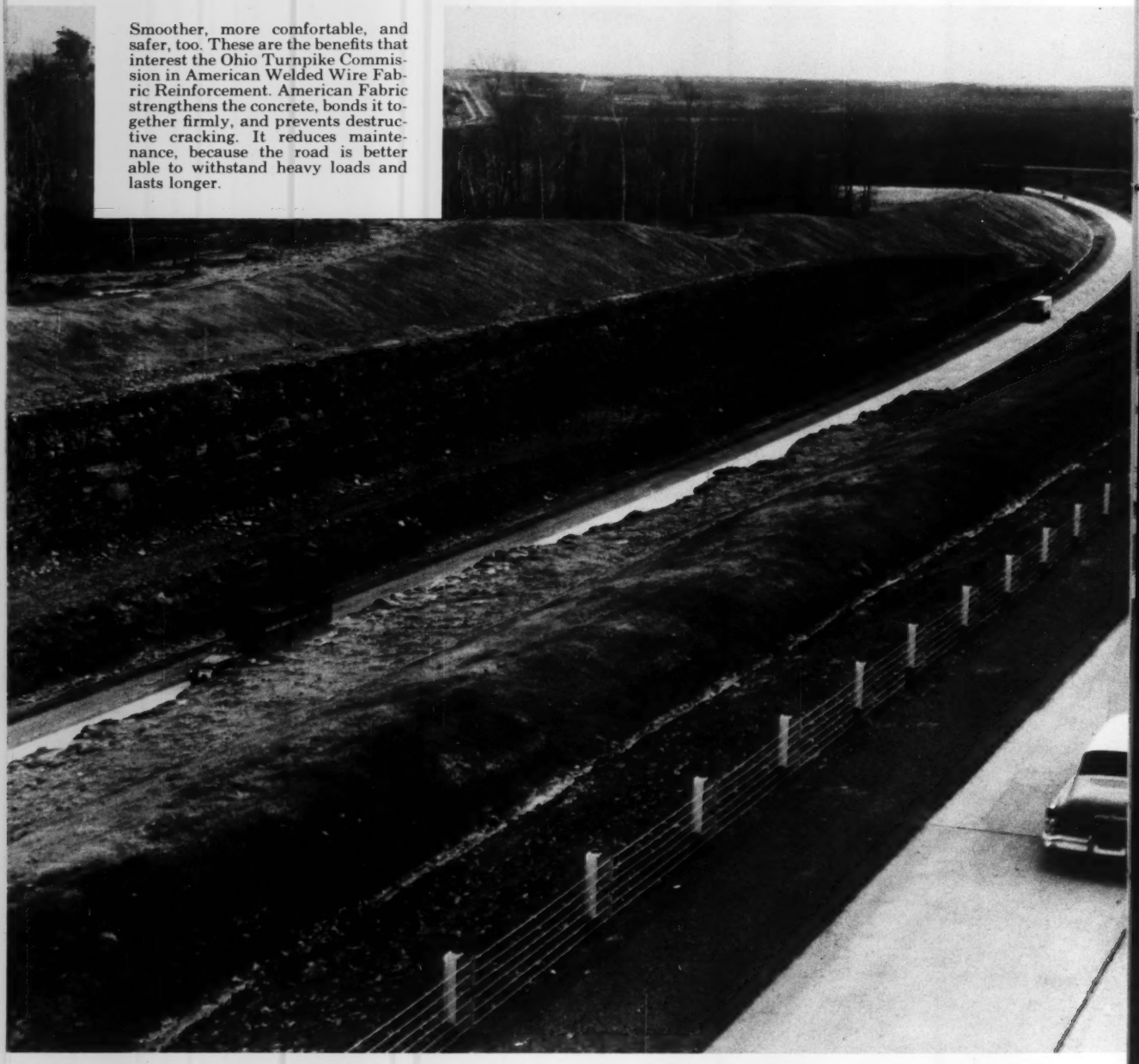
You will find interesting new applications of these fine products on the next few pages. We think it will be worth your while to read on.



On a great "AMERICAN" road

. . . American Fabric and Road Joints reduce
. . . American Highway Guard reduces fatal

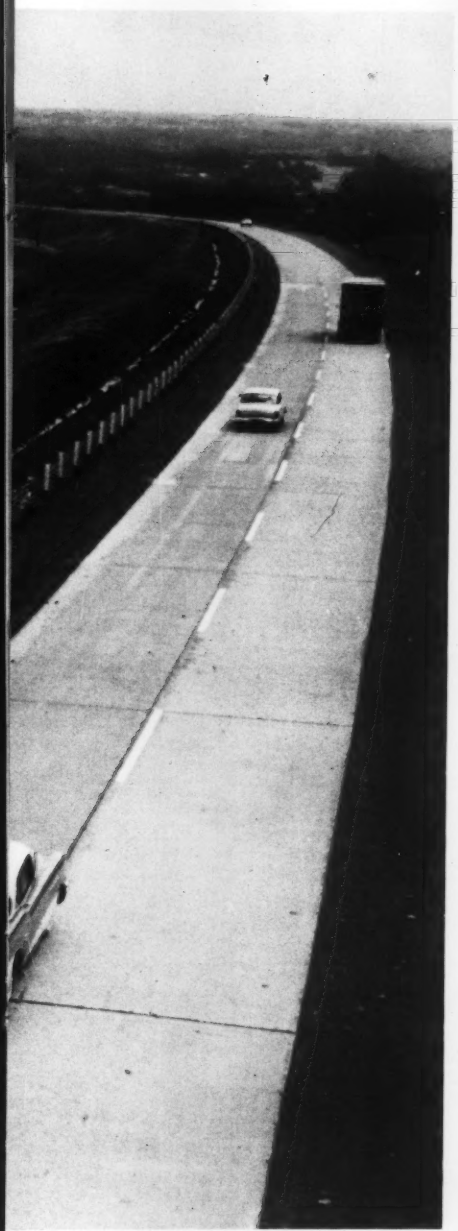
Smoother, more comfortable, and safer, too. These are the benefits that interest the Ohio Turnpike Commission in American Welded Wire Fabric Reinforcement. American Fabric strengthens the concrete, bonds it together firmly, and prevents destructive cracking. It reduces maintenance, because the road is better able to withstand heavy loads and lasts longer.

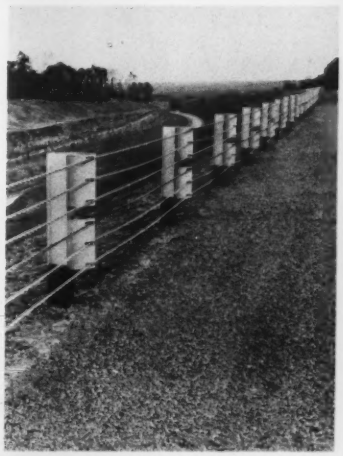


USS American Welded Wire Fabric

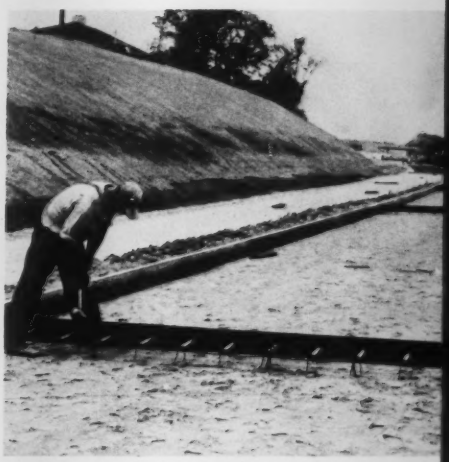
—THE OHIO TURNPIKE

maintenance accidents





Multisafty Cable Highway Guard makes this section of the famous Ohio Turnpike safer. The precipitous drop needed extraordinary protection. A special six-cable Multisafty Guard was designed to assure maximum protection. Elsewhere on the turnpike, four cables were used.



The longer reinforced slabs on the Ohio Turnpike provide a low cost, smooth-riding surface. And specially designed American Road Joints were used to keep the slabs in proper alignment and to provide adequate load transfer for a balanced pavement design.

Expanded facilities for the manufacture of American Welded Wire Fabric now make it readily available in wire sizes up to and including ½″ in diameter, at 2″, 3″, 4″, and 6″ on center. American Fabric increases the life of both Portland Cement Concrete and asphaltic concrete pavements. It meets ASTM Specification A 185-53T.

When it comes to safety, remember that USS Multisafty Cable Highway Guard protects in two ways: it restrains uncontrolled vehicles and it cushions the impact of collision between vehicle and guard.

Send this coupon for complete facts about American Steel & Wire products that can increase the safety and help reduce the long-term cost of your roads.

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- ☐ American Welded Wire Fabric for Asphaltic Concrete
- ☐ American Welded Wire Fabric for Airport Runways
- ☐ American Road Joints
- ☐ Multisafty Highway Cable Guard
- ☐ American Beam-type Highway Guard
- ☐ American Wire and Strand for Prestressed Concrete

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USS Multisafty Highway Guard

USS

UNITED STATES STEEL

3 MORE GREAT "AMERICAN" ROADS

John Lodge Expressway strengthened with American Welded Wire Fabric

This outstanding urban thruway and its companion, the Edsel Ford Expressway, in Detroit, were reinforced with American Welded Wire Fabric for longer life, reduced maintenance.

Maine Turnpike protected with American Highway Guard

On this particular section of the Maine Turnpike, highway engineers preferred a beam-type guard and American Steel & Wire supplied it. On other sections of this important northeastern road, USS Multisafty Cable Highway Guard is being used.

Indiana Toll Road strengthened with American Road Joints

Scheduled for completion late this year, the new Indiana Turnpike is another important link in a growing network of East-West superhighways. American Welded Wire Fabric, together with adequately reinforced joints, provides maximum corner protection for this concrete pavement.

For complete information about Construction materials manufactured by American Steel & Wire, send the coupon on the previous page.

USS American Welded Wire Fabric
USS Multisafty Highway Guard

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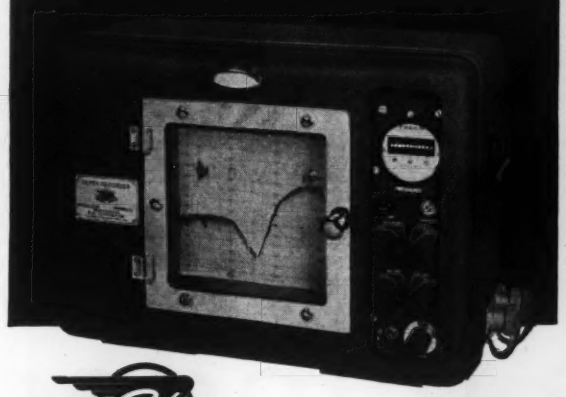
UNITED STATES STEEL

For Economical, Extremely Precise UNDERWATER SURVEY WORK...



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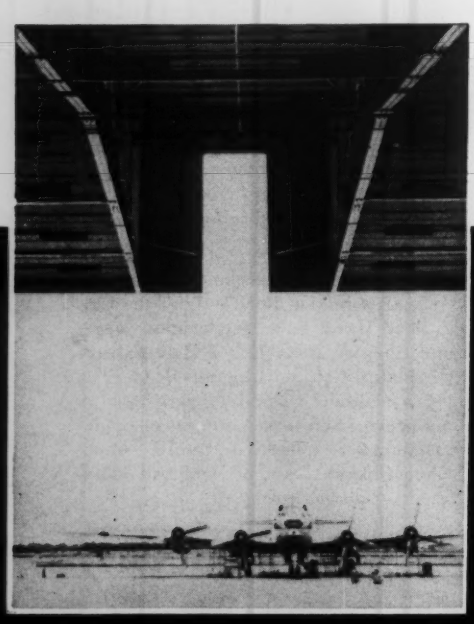
The 76-foot-long member which connects the top ridge of the cantilever to the top of the inner column is designed to act either in tension or compression—supports weight of roof loading, and withstands 30 psf uplift from wind under roof.

Ingenious hangar



Vertical clearance rises to 45 feet inside the three tail housings which open at the edge of the overhanging roof to admit the tails of these Boeing Stratocruisers.

The unique hangar was designed and constructed by the Erwin-Newman Co., of Houston, Texas, under their patent No. 2,687,102.

The hangar is designed for 25 psf roof load and 15 psf horizontal wind force. Rear columns are bolted to deep concrete piers since they must withstand a pull of 14 tons per column from the weight of the cantilevered roof structure, which amounts to only 11.8 psf.

has no columns...

cantilever construction spans 120 ft. at cost of only $2.40 per sq. ft.

• The hangar area of this efficiently-designed building of Temco Aircraft Corporation at Greenville, Texas, is completely unobstructed by supporting columns. The clear area measures 120 ft. deep x 432 ft. long x 30 ft. high.

The roof is carried on 120 ft. steel truss cantilevers, connected by means of rocker joints to 56 ft. tall inner columns, which in turn are joined to 19 ft. outer columns placed 40 feet farther back. The space between the two rows of columns is conveniently used for workshops, parts storage, and offices.

The prefabricated Structural Steel framework for this hangar was bolted together in *only six working days*. The framing cost $2.40 per sq. ft. Framing and roofing cost $3.26, and the complete building including services, foundations, and 32,400 sq. ft. of concrete apron totaled $5.06 per sq. ft. Approximately 1,000 tons of Structural Steel were used in the building framework. Speedy construction was an important factor in holding down costs.

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New Publications

Soil studies . . . The Proceedings of the Second National Conference on Clays and Clay Minerals—sponsored jointly by the National Research Council, the University of Missouri, and the State Geological Survey of Kansas and held at the University of Missouri in 1953—are now available in a 500-page volume. Ada Swineford and Norman Plummer are the editors. Identified as Publication 327, the volume may be obtained from the National Research Council, 2101 Constitution Avenue, Washington 25, D.C. The price is $4.

Treated timber piles . . . Economies and advantages of creosoted timber foundation piles are featured in a recent authoritative booklet, published by the American Wood Preservers Institute and entitled "Pressure Treated Timber Foundation Piles." Carefully documented with case histories, the 66-page treatise includes pile-driving formulas; means for determining safe loads; methods of solving problems of uplift and lateral forces; protective devices for use during driving; a résumé of the important building codes; specifications of the ASTM for use in selecting timber piles; standards of the American Wood Preservers' Association for preservative treatment; and test pile driving and test loading. Free copies of the booklet are available to architects, engineers, and builders, upon request to the American Wood Preservers Institute, 111 W. Washington St., Chicago 2, Ill.

Sewage treatment plants . . . A 28-page illustrated catalog describing its system of standardization in building construction has been published by the Luria Engineering Company, of Bethlehem, Pa. Entitled "Building by Luria," the catalog covers the company's complete line of standardized steel structures and hangars and other airport structures. Requests for copies should be forwarded on company stationery to the Luria plant at Bethlehem or the executive offices at 511 Fifth Avenue, New York 17, N.Y.

Engineering data on titanium . . . "Facts about Titanium" contains a list of the commonly available titanium alloys and their composition, forming and welding methods, heat treatment and machining information, as well as current and projected prices and other pertinent data. The pocket-size folder also includes a comparison of titanium properties with those of a stainless steel and aluminum alloy. Inquiries should be addressed to Arthur D. Little, Inc., Mechanical Engineering Division, 30 Memorial Drive, Cambridge 42, Mass.

Urban development . . . How to meet such critical urban problems as congestion, blight, and failure to use tax resources is discussed by the Chamber of Commerce of the United States in a recent publication, "Urban Development Guidebook." Based on findings obtained in urban development conferences sponsored in six cities with outstanding development programs, the guidebook recommends an overall approach to problems of community growth and change. Copies are available from the Chamber of Commerce of the United States, Washington, 6, D.C., at $1 each or 50 cents each in lots of three or more copies.

Construction reference . . . The eleventh edition of "Facts and Figures," a 100-page booklet published by Pioneer Engineering Works, Inc., rounds up information invaluable to persons in the highway, heavy-construction, or other basic industries. The present edition of the popular pocket-size reference represents 100 percent expansion of the last previous edition, which was published in 1950. Free copies are available from Pioneer Engineering Works, Inc., 1515 Central Avenue, Minneapolis 13, Minn.

Highway construction . . . In "Modernizing the Nation's Highways," the Committee for Economic Development presents the statement on national highway policy of its Research and Policy Committee. Inquiries concerning the 27-page study should be sent to the Committee for Economic Development, 444 Madison Avenue, New York 22, N.Y.

Surveying . . . Availability of a third edition of "Elementary Surveying," by Russell C. Brinker and Warren C. Taylor, Members ASCE, is announced. The present edition of this classic text has been completely rewritten and expanded, with greater emphasis on the theory of errors and optics, the use of significant figures, and practical field methods. The 550-page volume sells for $5.50 and is available from the International Textbook Company, Scranton 9, Pa.

Traffic control . . . In "Traffic Engineering and Control in the U.S.A.," present-day American attempts to solve traffic problems are reported by an O.E.E.C. mission of European road engineers and town planners, who visited the United States in the summer of 1954. The 188-page publication covers highway administration and finance, traffic and town planning, road and street design, parking, traffic laws and regulations. It sells for $1.25 and may be obtained from the Organization for European Economic Cooperation, Publications Office, 2000 P. Street, N.W., Washington 6, D.C.

Residential construction . . . "How to Build Nailed Trussed Rafters" is the title of a 50-page study prepared by E. George Stern, M. ASCE, research professor of wood construction at Virginia Polytechnic Institute and reprinted by the "Practical Builder," 5 South Wabash Ave., Chicago 3, Ill. Based on experimental data obtained in the Wood Research Laboratory under auspices of the Independent Nail and Packing Co., Bridgewater, Mass., the designs include W-type trussed rafters for spans from 18 to 36 ft, and pitches from 2 to 6 in 12. The trusses are designed for 35-lb live and dead roof loads and a 10-lb ceiling load. Inquiries should be addressed to the "Practical Builder."

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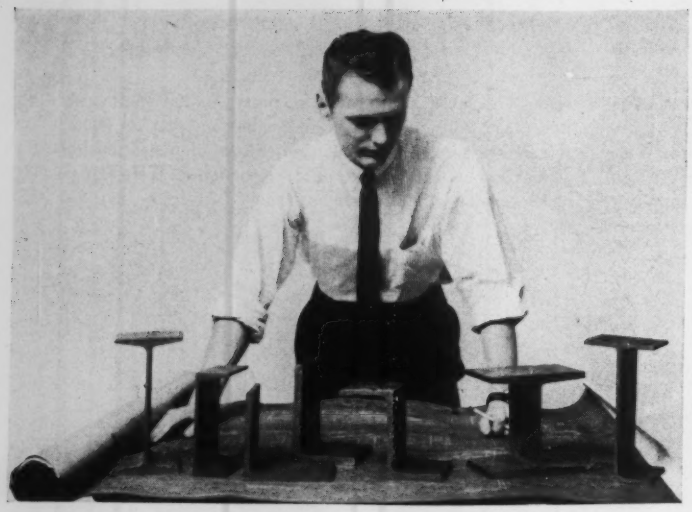
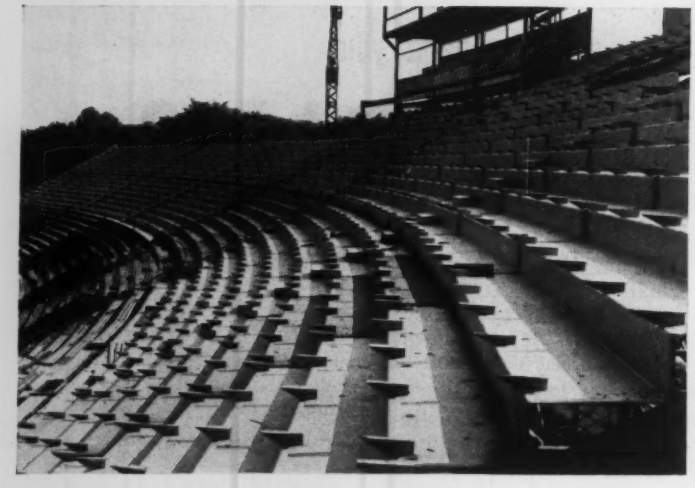
As a major supplier to the construction industry, Inland has consistently expanded and modernized its facilities to provide the new and better structural steels that help you design better and build better . . . for less. For more about Inland products for the construction industry, please turn the page.



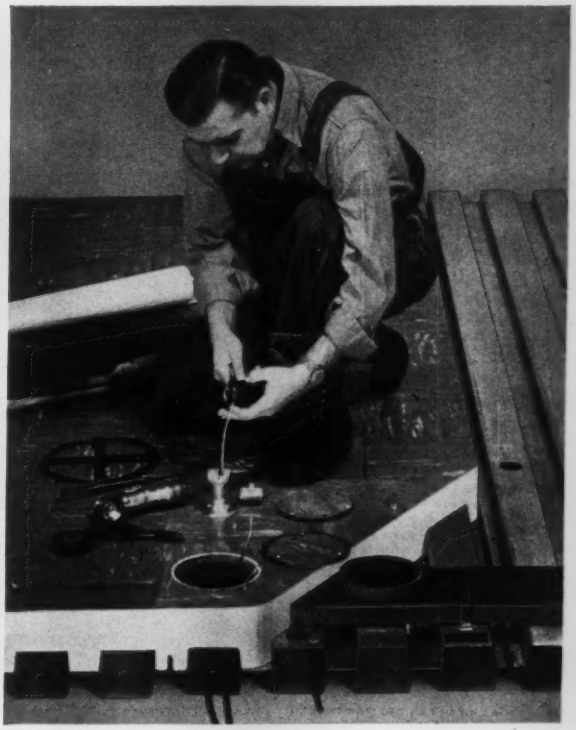
A COMPLETE LINE of structural steel shapes, including Wide Flange Beams, Wide Flange Light Beams, Wide Flange Joists, American Standard Beams, H-Beams, American Standard Channels, Equal Angles, Unequal Angles, Zees, and Bulb Angles, in the sizes you need, are available at Inland.

INLAND SUB-PURLINS are especially designed to provide a lighter, more efficient member for poured or pre-cast tile roof construction. Rolled from selected rail steel, they are cut to fit your particular job. They can be quickly and easily installed, without waste, providing lateral support, bridging or anchoring for the main purlins.



RUGGED INLAND 4-WAY* SAFETY PLATE offers a wide variety of ways to cut construction costs and make almost any structure safer and easier to maintain. Rolled from open hearth steel, 4-WAY can be used to provide structurally strong floors, ramps and stairs, often eliminating sub-floors and extra bracing. Specially designed slip-resistant tread provides safe traction for feet and wheels.

CELLUFLOR simplifies design, speeds construction, reduces costs.



CELLUFLOR provides for in-floor wiring to outlets any place any time at low cost.

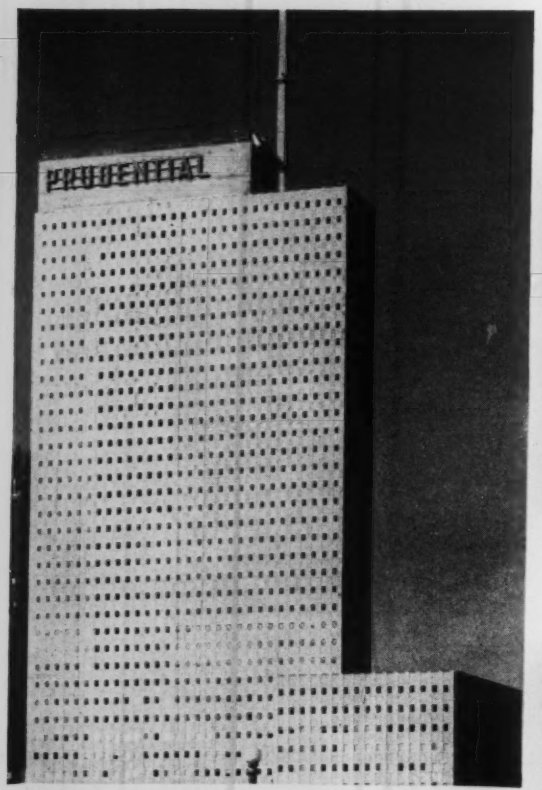
MILCOR CELLUFLOR* PERMITS LIGHTWEIGHT DESIGN, SPEEDS CONSTRUCTION AND PROVIDES ELECTRICAL FLEXIBILITY

MILCOR CELLUFLOR, manufactured by Inland Steel Products Company of Milwaukee, illustrates how engineering with steel can result in more functional design and lowered building costs. CELLUFLOR permits engineering freedom for the design of the newest light weight structures. Once installed, it provides a perfect work and storage platform for all trades.

Because it is made of durable Inland TI-CO Galvanized Steel, CELLUFLOR easily withstands the ravages of weather and construction traffic. In the finished building, CELLUFLOR insures electrical flexibility required to meet tomorrow's wiring needs. Its raceways, spaced on 6-inch centers, permit the installation of power anywhere. Outlets may be easily moved at low cost.

MILCOR STEEL ROOF DECK, long the standard of closed-rib decks, is now available in three new profiles—each with special features to fit job requirements. All three styles are quickly erected in any weather, all are available with either a TI-CO galvanized finish or with a baked enamel prime finish on a Bonderized base. Typical of a low-cost Milcor Roof Deck application is the Milwaukee County Stadium (left), home of the Milwaukee Braves. Milcor Steel Roof Deck was used to cover the stands. A bonded roof coating of asphalt insulation and 3 ply roll roofing was then applied to the top of the deck.

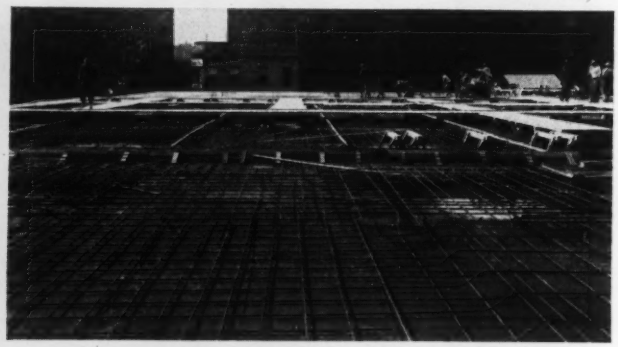
**Registered Trade Mark*



MORE THAN 1,000 TONS of Inland TI-CO* galvanized sheets went into the duct work and air handling equipment for Chicago's giant Prudential Building. TI-CO galvanized sheets were specified for the job (largest sheet metal installation in the Midwest) because the zinc coating stands up under the toughest punishment without cracking, flaking or peeling, keeping rust sealed out. TI-CO sheets are made by a patented continuous galvanizing process which applies a zinc coating that is extremely tough, yet just flexible enough to resist hammering, bending and lock-seaming without cracking.

**Registered Inland trade name*

A GOOD MAN TO TALK TO when it comes to engineering or estimating problems is your Inland representative. Through him you draw on the wide experience of Inland specialists in construction problems. You'll get expert help in selecting steels and estimating costs.



INLAND HI-BOND* REINFORCING BARS have deep, reversed, double-helical ribs which provide a mechanical grip to give maximum bond in concrete, thus permitting greater use of steel's potential strength in concrete construction. HI-BOND's design also improves transfer of stresses, crack control and resistance to slip . . . advantages that will make possible higher design stresses and thereby lower construction costs. HI-BOND meets standards set up by ASTM A305.

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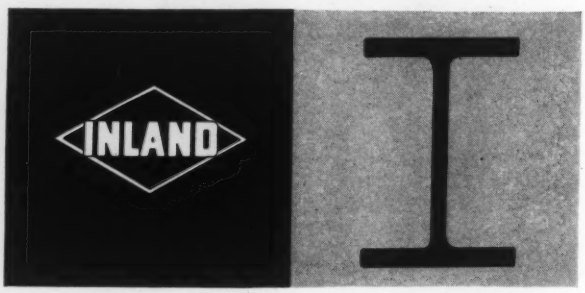
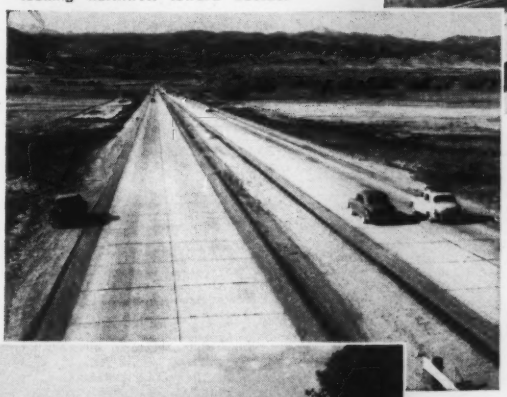
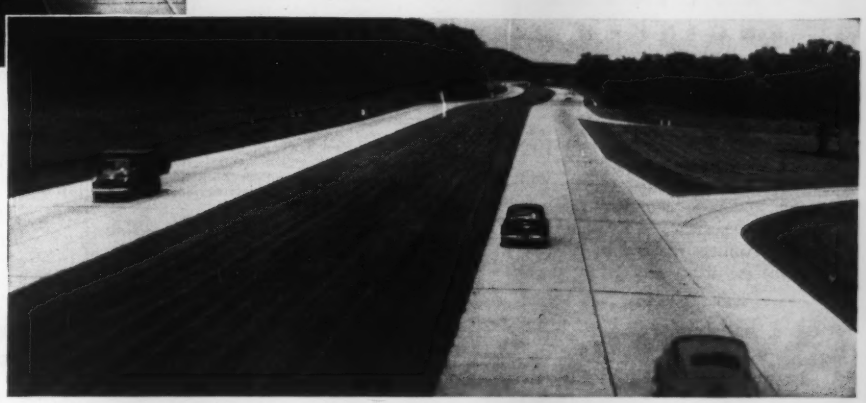


The Pennsylvania Turnpike about 8½ miles east of the Ohio line

Colorado's Denver-Boulder Turnpike looking northwest toward Boulder



The West Virginia Turnpike soars across rugged mountains



The New York Thruway will be the longest of all when completed

CONCRETE IS 1ST CHOICE FOR TOLL ROADS, TURNPIKES

Concrete is the overwhelming choice for America's toll roads and turnpikes. Of 3,132 miles now operating, under construction or for which the type of pavement has been selected, 2,099 are concrete.

There are four major reasons why engineers consistently choose concrete for toll roads and turnpikes: (1) they can design it *accurately* for any load and it will *keep* that load-carrying capacity for life, (2) it has twice the life expectancy of any other pavement, (3) it costs much less to maintain and (4) it has the highest annual earning power.

Toll roads must pay for themselves out of tolls. Consequently the moderate first cost, low maintenance cost and the long service life of concrete are important factors in a road's earning power.

Helpful, free literature on designing concrete roads is available but is distributed only in U.S. and Canada.

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This placement service is available to members of the Four Founder Societies. If placed as a result of these listings, the applicant agrees to pay a fee at rates listed by the service. These rates—established to maintain an efficient nonprofit personnel service—are available upon request. The same rule for payment of fees applies to registrants who advertise in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York Office. Please enclose six cents in postage to cover cost of mailing and return of application. A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription rate of $3.50 per quarter or $12 per annum, payable in advance.

Men Available

CHIEF ESTIMATOR, PROJECT MANAGER, CONSTRUCTION EXECUTIVE; J.M. ASCE; in heavy construction. Experienced in highways, bridges, sewers, water works, waterfront work, foundations and railroad work; 10 years in office and field with varied experience in costs and actual construction. Has handled projects from bidding to completion. Location preferred, New York City and vicinity. C-127.

CIVIL ENGINEER; A.M. ASCE; B.E. in civil; M.Sc. in civil engineering, University of Utah; 39; married; immigrant; 8 years' experience in highway design, location, construction, and maintenance; 3 years in charge of a highway materials, testing, and research laboratory. Desires position in a concrete or soils testing and research laboratory. C-128.

CHIEF ENGINEER, PIPELINE ENGINEERING FIRM; A.M. ASCE; M.S. in civil engineering; 35; married. Experience in industrial, consulting, teaching, research. Specialties, hydraulics and industrial instrumentation. Desires associate professorship with opportunity for consulting; available fall term. C-129.

SANITARY ENGINEER; A.M. ASCE; Dipl. Eng; 39; married; 9 years' experience in design and preparation of plans and specification for sewage and water-treatment plants, together with design of the relevant reinforced concrete structures and supervision of resident engineer, in Germany, France, and South Africa. Will be available June 1. Location preferred, southern California C-130.

CHIEF ENGINEER, PLANT ENGINEER OR ADMINISTRATIVE ASSISTANT; A.M. ASCE; registered P.E.; 41; with management potential, strong diversified experience, special chemical processing equipment, automatic machinery, construction, plant layout, budgets, estimates, project and development work. C-131.

CIVIL ENGINEER; J.M. ASCE; 26; married; BSCE; MSE master's soil mechanics; completing 3 years as commissioned officer, Navy Civil Engineer Corps, including 18 months as resident-officer-in-charge-of-construction duty. Desire position with a consulting or testing firm associated with soils and foundation engineering. Will locate anywhere, but preferably East Coast. C-132.

Positions Available

JUNIOR CIVIL ENGINEER, graduate since 1950, for large construction company engaged in all kinds of heavy construction in eastern United States. Salary open. W-3027.

SANITARY ENGINEER, graduate in civil, sanitary, public health, chemical, general or architectural engineering; 4 years' experience in sanitary engineering or M.S. degree in sanitary engineering or public health and 3 years' experience. Will perform administrative and professional engineering work in development and application of sanitary measures for prevention and control of diseases caused by environmental factors such as municipal water, sewage disposal, etc. Salary, $5,604–$6,780 a year. Location, South. W-3030.

ENGINEERS. (*a*) Superintendents, experienced in general building construction and some specific experience in reinforced concrete work. Salary, $9,100–$11,700 a year. Location, east of the Mississippi. (*b*) Estimator, in building work, some experience in reinforced concrete work. Salary, $7,020–$7,800 a year. Location, Massachusetts. W-3057.

JUNIOR STRUCTURAL DESIGNER, graduate civil, with from 2 to 5 years' experience on bridge and highway design and some field contact. Salary, $5,920–$6,500 a year. Location, Connecticut. W-3072.

RESIDENT ENGINEER, with construction and plant engineering experience in Latin America to supervise installation of gas-turbine-driven generators. Salary, $10,000–$12,000 plus extras, a year. Location, Colombia, South America. F-3086.

CIVIL ENGINEER, young, B.S. or M.S., preferably with 1 to 2 years' experience in civil engineering, to work as general engineering assistant; work will involve design, drafting, specifications, field work, inspection, and related duties as assigned. Occasional traveling. Salary, $6,000–$6,500 a year, expenses paid when traveling. Headquarters, New York, N. Y. W-3089.

PROJECT MANAGER, civil graduate, 35–48, with at least 10 years' design, project engineering, and construction management experience covering water supply, roads, and general public works construction. Salary, $12,000 a year, plus extras. Location, Middle East. F-3090.

INSTRUCTOR, young, M.S., civil engineering, to head up department. Salary open, depending upon qualifications. Location, Pennsylvania. W-3111.

CONSTRUCTION SUPERINTENDENT, with at least 10 years' commercial building experience to supervise multi-story steel and concrete office building. Salary, $10,000–$12,000 a year. Location, Florida. W-3121.

STRUCTURAL ENGINEER, civil graduate, with design and project engineering experience in industrial construction for staff position covering design, layout and specifications, with food processing manufacturer. Salary, $7,500 a year. Location, southern Michigan. W-3126.

ASSISTANT ENGINEER OR CITY PLANNER, recent graduate civil, with some courses in city planning, or one with 1 to 2 years' experience in municipal engineering. Salary, $4,200–$5,400 a year, to start. Location, New York, N. Y. W-3133.

STRUCTURAL ENGINEER, with 10 to 15 years' experience in structural design, detailing and checking experience on bridges and buildings. Must be thoroughly familiar with shop details, concrete details, construction practice, and engineering drawings. Location, South. W-3143.

ASSISTANT CHIEF ENGINEER, civil graduate, 30–45, degree and experience in structural drafting and crane design. Will do selling, supervision, design, and drafting. Salary, $7,200 a year. Location, Midwest. W-3150-C.

CHIEF ESTIMATOR, with considerable experience in all phases of industrial construction engineering, i.e., chemical plants, refineries, and oil buildings. Location, New York, N.Y. W-3164 (*a*).

(*Continued on page 122*)

Structural architectural engineer with steam electric and hydro-electric power plant experience to supervise structural steel design, prepare specifications, inquiries and purchase requisitions. Experience in other fields of engineering desirable.

STRUCTURAL ENGINEER

Position with large New York engineering and construction firm. Regular staff position with liberal company benefits. Salary commensurate with experience. Excellent opportunity for future advancement.

Please submit complete resume to:

Box 273

American Society of Civil Engineers
33 W. 39th St. New York 18, N. Y.

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Opportunities for both experienced and inexperienced mechanical and civil engineering graduates.

Training program available to supplement technical background and experience.

Barber-Greene is one of the oustanding growth companies, which offers life-time careers to outstanding men.

Submit resume outlining background, salary desired, etc., to: Personnel Manager

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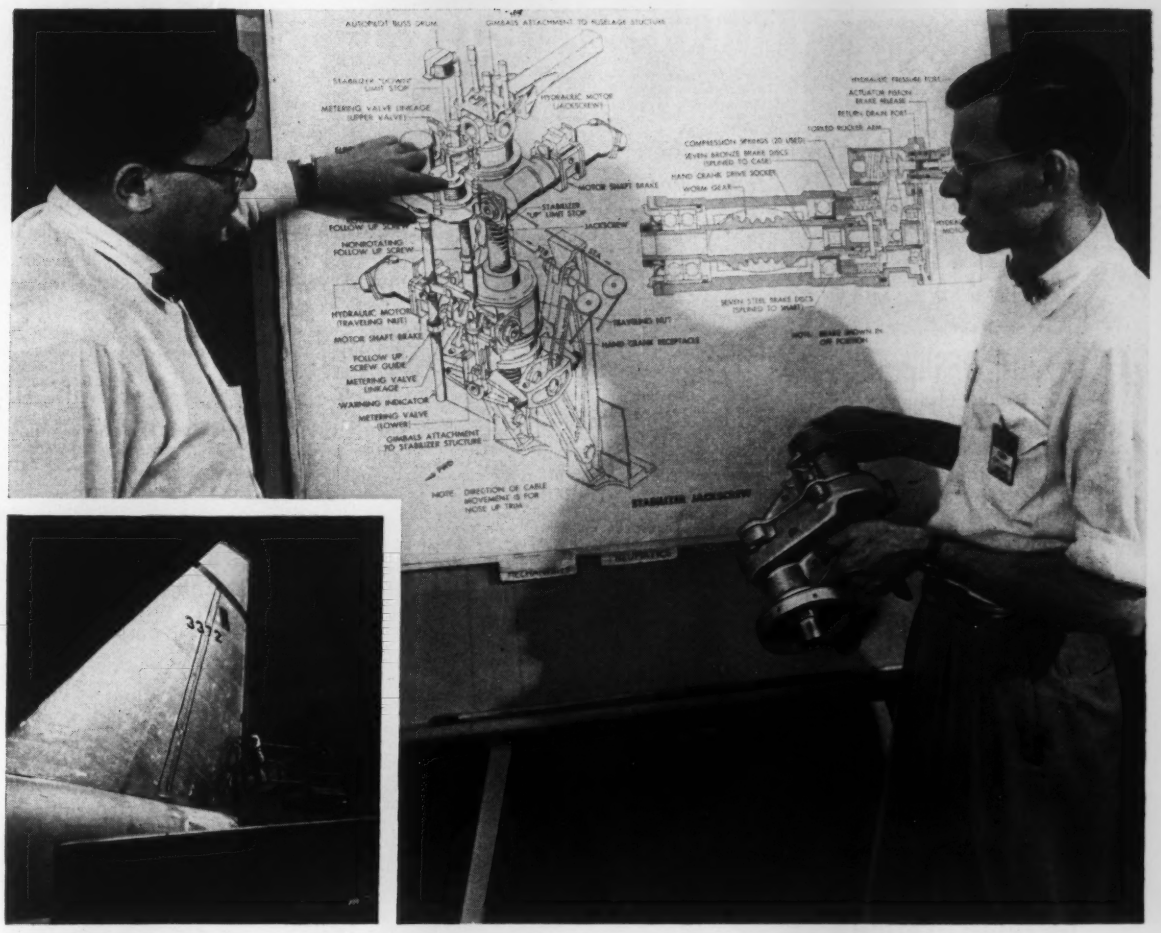

B-52 jack screw—a typical Boeing design challenge

On Boeing B-52 bombers, the horizontal tail surface has more area than the wing of a standard twin-engine airliner. Yet it can be moved in flight, up or down, to trim the aircraft.

The device that performs this function is a jack screw, which, though it weighs only 255 pounds, can exert a force of approximately 225 *tons!*

Much civil engineering skill went into designing and developing the supports for the jack screw and the mechanism itself. This is so precise that it can automatically compensate for stretch and compression under load. Civil engineers find challenging work on design projects for the B-52, and for the 707 jet tanker-transport, the BOMARC IM-99 pilotless interceptor, and future aircraft. Thanks to draftsmen and aides, Boeing "C.E.'s" are free to do highly creative design work.

Because of Boeing's steady expansion, there is continuing need for additional engineers. There are more than twice as many engineers with the company now as at the peak of World War II. Because Boeing is an "engineers' company," and promotes from within, these men find unusual opportunities for advancement.

Design engineers at Boeing work with other topnotch engineers in close-knit project teams. They obtain broad experience with outstanding men in many fields, and have full scope for creative expression, professional growth and individual recognition. And they find satisfaction in the high engineering integrity that is a Boeing byword.

In addition to design engineering, there are openings on other Boeing teams in research and production. Engineers and their families like the life in the "just-right" size communities of Seattle and Wichita. They may pursue advanced studies with company assistance in tuition and participate in a most liberal retirement plan. There may be a place for *you* at Boeing-Seattle or Boeing-Wichita.

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Boeing Airplane Co., Dept. D-51, Wichita, Kansas

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Co., Dept. D-51, Seattle 14, Wash.

If you want further information on the advantages of a career with Boeing, please send coupon to either of the above addresses.

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GRUMMAN AIRCRAFT
Engineering Corp.
Bethpage, N. Y.

Men and Jobs Available

(*Continued from page 120*)

CONSTRUCTION ENGINEER, under 30, civil graduate, with design, layout, and field engineering experience in military service, highway or railroad construction, for staff position in office of chief engineer. Salary, $6,600–$7,200 a year. Location, Pennsylvania. W-3181.

ASSISTANT CIVIL ENGINEER, graduate, with some construction experience, for public works department. Salary, $4,600 a year, to start. New Jersey resident preferred. W-3201.

ENGINEER, mechanical or civil, 25–30, with 5 years' experience in construction and maintenance of buildings, equipment, and services. Salary open. Location, Massachusetts. W-3215.

ENGINEERS. (*a*) Assistant Executive Director, degree in civil engineering, architecture, landscape engineering, landscape architecture, or city planning, with 6 years' experience in all principal phases of city planning, including at least 2 years' experience in supervision and administrative operations. Master's degree counts for one year's experience. Salary, $7,500 a year. Location, upstate New York. (*b*) Director of Research and Public Information, degree; master's degree counts for one years' experience, with a minimum of 4 years' experience in city planning and governmental research, public information, and work with groups. Salary, $6,100 a year. Location, upstate New York. W-3226.

BITUMINOUS PAVING CONSULTANT to head up research program on well known new paving material. Finest laboratory facilities; excellent opportunity with international organization. Salary, first year, approximately $15,000. Location, Atlantic seaboard. W-3231.

ENGINEERS for sanitary engineering consulting firm. (*a*) Specification Writer; (*b*) Structural Designer; (*c*) Sanitary Engineers; (*d*) Draftsmen. Salary plus fringe benefits. Location, New York, N.Y. W-3232.

ASSISTANT RESEARCH ENGINEER—HYDRAULICS, B.S. in civil or (better) hydraulics major, with some practical laboratory experience, to supervise testing of hydroelectric models and other hydrualic laboratory projects. Must know laboratory procedure and write engineering reports. Work under head of Hydraulic Section. Salary, $5,500–$6,000 a year. Location, Northwest. S-1532.

DISTRICT SALES—BUILDING MATERIALS, to 50 with 3 or more years' experience in sales management, to supervise district sales force, selling building materials to architects, engineers, and contractors. Some travel; car required. Salary, $10,000–$15,000 a year, plus bonus and expenses. Employer will pay placement fee. Location, Chicago. C-4759.

ASSISTANT RESEARCH ENGINEER, M.S. in hydraulics, will supervise testing of hydroelectric models and other hydro laboratory projects. Experience should include responsible engineering in laboratory procedures, and in report writing. Salary, $6,000 a year, plus, depending on experience and training. Location, State of Washington. C-4784.

INSTRUCTOR, B.S.C.E., 30, with 2 years' experience in surveying and mapping. Will instruct in civil engineering subjects, mainly surveying courses. Salary, $4,800–$5,500 a year. Location, Midwest. C-4792.

Applications for Admission to ASCE March 17–March 31, 1956

Applying for Member

PHILIP PAUL AMPOLLINI, Pleasantville, N.J.
JAMES KREMER ARENTZ, Greensburg, Pa.
FRANCIS ANDREW BANTON, New York, N.Y.
ROBERT MAXWELL BECKER, Boston, Mass.
CHARLES HENRY BOERNER, Honolulu, T. H.
GUTTORM NILSEN BREKKE, Washington, D.C.
EDWARD HARRY COOK, Atlanta, Ga.
JOSEPH KENNETH CREMANS, Juneau, Alaska.
RALPH EARL DAVIS, Kirkwood, Mo.
ROBERT JEROME DAVIS, Detroit, Mich.
ALEXANDER WILLIAM DOUGLAS, North Branford, Conn.
RUSSELL RAYMOND EKSTROM, Walla Walla, Wash.
ROBERT EDWARD EVANS, Chicago, Ill.
SAMUEL DEWITT FARMER, Rolla, Mo.

(*Continued on page 124*)

HYDRAULIC ENGINEER

New York consulting firm has opening for an engineer with sound basic knowledge of hydraulic principles. At least 15 years experience desired, preferably in the general field of electric power production or water supply. Work includes:

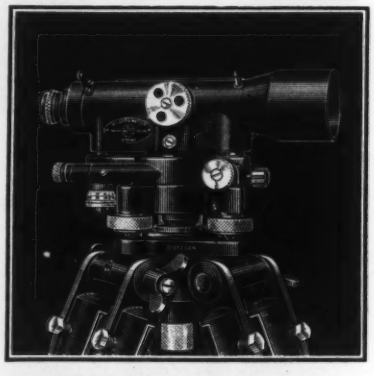
1 **Office and field engineering for dams, spillways, flow lines and hydro-electric stations.**

2 **Hydrological studies of surface and ground-water supplies.**

3 **Field investigations of sites for steam electric and hydro-electric stations including preparation of preliminary economic comparisons.**

Write giving complete details of experience, education and personal data. Please submit complete resume to:

BOX 272
AMERICAN SOCIETY OF CIVIL ENGINEERS
33 W. 39th St., New York 18, N. Y.



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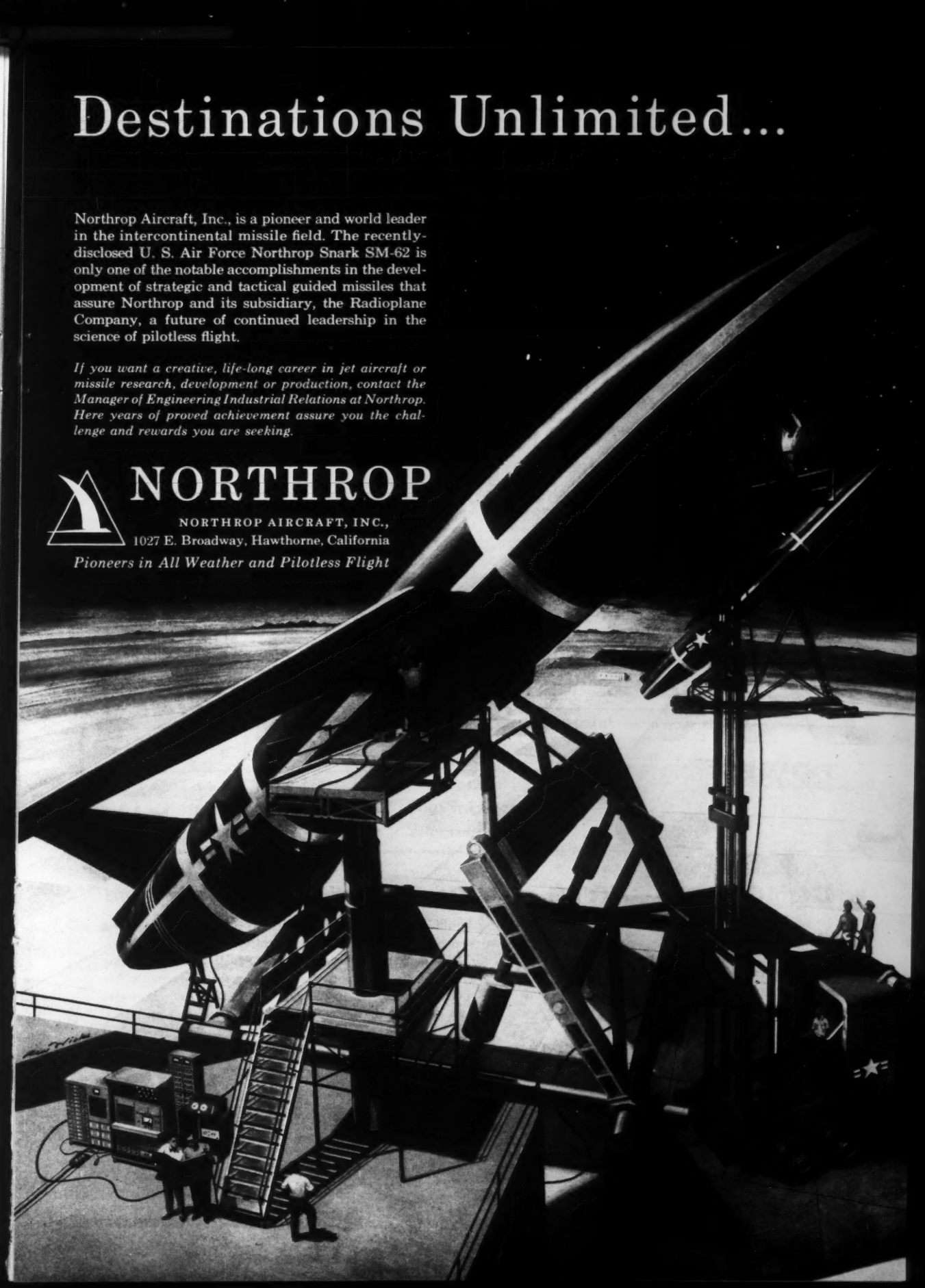

Applications for Admission

(*Continued from page 122*)

ROBERT MASON HAIR, Kansas City, Mo.
JOSEPH EDWARD HARVEY, Sacramento, Calif.
LAURENCE DELBERT HOMAN, Baltimore, Md.
RUSSELL EUGENE HORN, York, Pa.
ARTHUR LEROY JOHNSTON, Omaha, Nebr.
GAYLORD COULTER KIPPING, Los Angeles, Calif.
JOHN RAYMOND LAPLANT, Westbrook, Me.
MORRIS ABRAHAM LISTON, Daly City, Calif.
NORMAN ARTHUR MATTHIAS, Seattle, Wash.
ERLE NEWTON MENEELY, Missoula, Mont.
LESTER ARTHUR ROBB, Beirut, Lebanon.
CLARENCE JOHN ROBIN, Norfolk, Va.
MERRITT ROSCO ROYER, Kansas City, Kans.
ANDERS BIRGER SANDQUIST, Pocasset, Mass.
BURTON ANTHONY SCHEIDT, Chicago, Ill.
IVAN FRANKLIN SHULL, Lawrence, Kans.
WILLIAM EDWIN SIMMONS, Beaumont, Tex.
JOHN WILLIAM SMITH, Palatine, Ill.
HUBERT GUSTAVE WICHMAN, Milwaukee, Wis.
ROBERT PAYNE WITT, Stillwater, Okla.
JOHN HENRY YAW, Pittsburgh, Pa.

Applying for Associate Member

DANIEL BETHENCOURT ABRIL, Havana, Cuba.
NEHALUDDIN AMANULLAH, Patna, India.
ROBERT LYND ANDERSON, Dhahran, Saudi, Arabia.
ROGER WILLIAM BARBEY, San Francisco, Calif.
EFREN BARRAGAN ROMERO, Caracas, Venezuela.
GLENN LESTER BEICHLEY, JR., Denver, Colo.
JOHN LOUIS BELL, Baltimore, Md.
CLIFTON NORMAN BELLAMY, Big Spring, Tex.
JOHN ROGER BLAIR, Effingham, Ill.
NICHOLS W. BOSWORTH, Redondo Beach, Calif.
HAROLD WILLIAM BURKE, Beirut, Lebanon.
RAYMOND MUIR BREMNER, Toronto, Canada.
YEAGER AUGUSTUS BUSH, Seattle, Wash.
MAYNARD PIERCE BROWER, Redding, Calif.
ROBERT LEROY BUSCHMAN, Fort Wayne, Ind.
PEDRO LAINEZ-LOZADA CAMPOS, Ciudad Triyillo, Peru.
BRUCE HEAD CANTRELL, Newport News, Va.
KENNETH EUGENE CARTER, Huntington, Station, N. Y.
RICHARD CHARLES CLANCY, Buffalo, N. Y.
RAY BISHOP COLLIER, Rolla, Mo.
JOHN HUBERT DUCHKAR, Alliance, Ohio.
BURKE ALLEN DRAHEIM, San Diego, Calif.
DAVID HAMILTON ELLIOTT, Riverdale, Md.
KENNETH BENJAMIN FICK, St. Paul, Minn.
STERLING BIRD FREEMAN, JR., El Paso, Tex.
LELAND FAUNTLEROY GRANT, Knoxville, Tenn.
RICHARD WALLACE GUNN, New Haven, Conn.
ARTHUR HALL, La Paz, Bolivia.
EDWARD SIGUARD HARALDSON, JR., Houston, Tex.
CLARENCE EUGENE HAWKINS, Rolla, Mo.
JOHN WALKER JAMES, San Andreas, Calif.
CLEBURN CATON JOBE, Gainesville, Fla.
RAY WILSON JONES, Sacramento, Calif.
JOSEPH EDWARD KALLBRIER, Rolla, Mo.
MARK MICHAEL KILBY, Boston, Mass.
VICTOR KNOWLTON, Oklahoma City, Okla.
ALEXANDER ERIC KRAMER, Glasgow, Scotland.
HANMANTRAO BAPURAO KULKARNI, Ottawa, Ont., Canada.
ANDRE LABRECQUE, Montreal, P.Q., Canada.
VERNER LEE LANE, South Bend, Ind.
ROBERT HENRY MACDONALD, West Springfield, Mass.
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JOHN HENRY MARTEN, Emerson, N. J.
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JOHN STANTON MEAD, Missoula, Mont.
ALAN JAY MICHAEL, New York, N. Y.
JOHN DOUGLAS ASHTON MOLLARD, Saskatchewan, Canada.
WILLIAM JOSEPH ROBERT NOWSON, Hong Kong, China.
ROLAND ARNOLD PEARSON, Aruba, North West Indies.
MICHAEL WLADIMIR PETROW, Detroit, Mich.
FRANCIS ALVIN RACSTER, Newman, Ill.
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J. D. ROETZEL, Rolla, Mo.
STANLEY CLAYTON ROGERS, La Mesa, Calif.
BASIL ROBERT SMITH, El Paso, Tex.
EUGENE WILLIAM SMITH, Lincoln, Nebr.
THOMAS MICHAEL STETSON, Los Angeles, Calif.
EDWARD OTTO STREICH, New York, N. Y.
JAMES BOYD SULLIVAN, New York, N. Y.
AUGUST JOHN SZABO, Lafayette, La.
PIETER WILLEM VAN AARTRIJK, Massena, N. Y.
RONALD ARCHIBALD WATERHOUSE, Dallas, Tex.
MAXWELL WILLIAM WHITE, Bethlehem, Pa.
CARL FRANCIS WHITEHEAD, Garden City, N. Y.
JAMES EDWIN WILSON, Stockton, Calif.
NATHAN DYER WILSON, Camp Hill, Pa.
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Applying for Junior Member

PETER ANDRU, Alberta, Canada.
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ROBERTO CALMON de BARROS BARRETO, Sao Paulo, Brazil.
AJIT KUMAR BHATTACHARYYA, Calcutta, India.
NORMAN JOSEPH COHEN, Union, N. J.
JOHN LEGRAND COTTON, Kansas City, Mo.
FERMAN VANCE DAVIDSON, Aurora, Minn.
HOSSAIN SEKANDER HAYAT KHAN EUSUFZAI, College Station, Tex.
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DOUGLAS WILLARD FLATT, Topeka, Kans.
EARLE SHERMAN FREEDMAN, Baltimore, Md.
BERNARD JOSEPH GOODAL, Champaign, Ill.
FRANKLIN MELIUS GORDON, San Francisco, Calif.
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VICENTE JIMENEZ, JR., Manila, Philippines.
WYNN EUGENE KAMPE, New York, N. Y.
GEORGE KANEKO, Honolulu, Hawaii.
PHILIP LAMBERT, Syracuse, N. Y.
ROBERT NEIL MCDOUGALD, Oakland, Calif.
HOWARD FRANKLIN MORRIS, Norfolk, Va.
FRANK RONALD MOSKOS, Detroit, Mich.
LEWLIE CLIFFORD NORONHA, Sao Paulo, Brazil.
FUAT ODAR, Yenisehir, Turkey.
RICHARD EDWARD O'REAR, Pasadena, Calif.
WILLIAM JAMES STANLEY ORR, Dayton, Ohio.
HARVEY GUS PENSHORN, San Antonio, Tex.
GERALD LEON PETERSON, Rolla, Mo.
DAVID NATHAN RAFFEL, Chicago, Ill.
MRIGENDRA NATH RAY, Kharagpur, India.
IGNATIUS FRANC.3 RIZZUTO, New York, N. Y.
GILBERT THOMPSON SATTERLY, JR., Detroit, Mich.
THEODORE PETER VANDE SANDE, Sacramento, Calif.
WILLIAM CUMINS SHAPIRO, Cambridge, Mass.
KENNETH ROY SMITH, Toledo, Ohio.
GRANT WILL WALKER, Sacramento, Calif.
CHARLES CHRISTIAN YOUNG, Sacramento, Calif.

[*Applications for Junior Memberships from ASCE Student Chapters are not listed*]

GAR-BRO Selection Chart

Equipment	Load Capacity	Maximum Travel Distance	Speed	Capacity* Per Hour
POWER-CARTS	9 to 12 cu. ft.	1000 ft.	15 mpr.	15 to 20 cu. yds.
CONCRETE-CARTS	6 to 8 cu. ft.	200 ft.	walking	3 to 5 cu. yds.
WHEELBARROWS	3 to 5 cu. ft.	200 ft.	walking	1 to 1½ cu. yds.

*according to hauling distance

"Designed with Concrete in Mind"

SELECTION OF EQUIPMENT is most important in planning any concrete job—it can make the difference between profit and loss. That's why Gar-Bro offers check lists to guide you in considering all job factors. Remember, Gar-Bro builds the only complete line of concrete handling equipment. And only Gar-Bro dealers can give you unbiased advice in the selection of the best equipment. Write for catalog!

Ask your dealer for a Gar-Bro Concrete Handling Manual

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GAR-BRO MANUFACTURING CO. • Los Angeles, California • Peoria, Illinois
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The world's most complete line of
Concrete Handling Equipment

WANTED! ENGINEERS TO HELP MAKE LONG RANGE MISSILE HISTORY

North American's Missile Projects Offer A New Engineering Adventure

With complete weapons system responsibility for the SM-64 NAVAHO Intercontinental Guided Missile, North American is engaged in one of the most challenging programs yet offered. But every inch of progress is a tough scientific battle. New means are daily being found to solve the complex problems which the development of long range missiles presents in the fields of structures, temperatures and aerodynamics. But most important of all, *men* must be found who thrive on this kind of challenge . . . men who are really excited about this new missile science. Are you one of them?

If you qualify in one of the fields we have listed below, chances are you can qualify for this unique expedition into the technology of the future. We would like to tell you about all the physical and professional advantages of a career in North American's Missile Development Engineering.

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Instrumentation Design, Development & Application **Standards, Drawings Checking, Specifications Writing**
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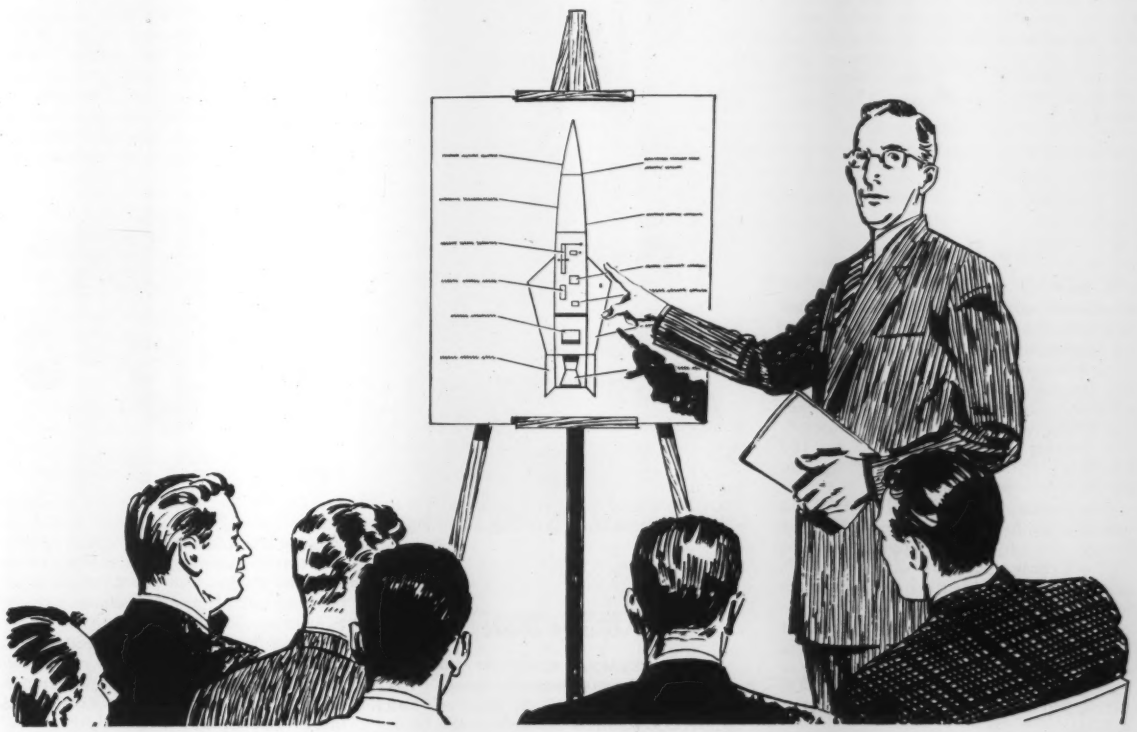
Missile Airframe Design **Hydraulic, Pneumatic & Servo Engineering** **Armament Systems & Components Engineering**
Aerodynamics **Engineering Flight Test** **High Temperature Materials Engineering** **Mechanical & Electrical Design**

Contact: R. L. Cunningham, Missile Engineering Personnel Office
Dept. 91-20CIV, 12214 Lakewood Boulevard, Downey, Calif.
Phone: LOgan 5-8651 Ext. 518
Interviews 8 A.M. to 9 P.M. Monday through Friday

NORTH AMERICAN AVIATION, INC.

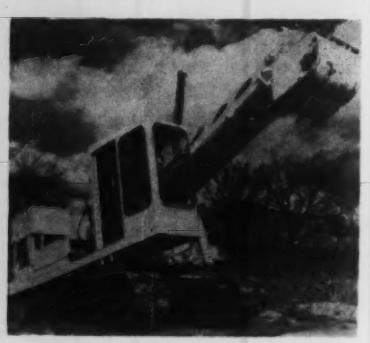


EQUIPMENT, MATERIALS and METHODS

NEW DEVELOPMENTS OF INTEREST AS REPORTED BY MANUFACTURERS

Crawler

A NEW AND COMPACT CRAWLER MODEL of the multi-purpose Gradall has just been announced. The crawler mount has been



Gradall Crawler

redesigned in this model for more power with two speeds available at full power both forward and backward. Simplified controls actuated with one lever regulate the speeds of the crawler which has a 44-hp engine. A selection of tracks ranging from 18-in. through 24, 30, to 48-in. make it possible to mount this model on tracks with as low as $3\frac{1}{2}$-lbs per sq in. in bearing pressure. The low speed with full power makes the new model easier to operate on steep grades than earlier models. **Warner & Swasey Company, CE 5-126, 5700 Carnegie Ave., Cleveland, Ohio.**

Form Protection

A PRODUCT that increases the life of wood or plywood concrete forms and which produces clean, smooth concrete surfaces by preventing concrete, mud and water from adhering is being manufactured under the name of Form Kote. Applied with either roller, brush or spray, it penetrates into wood and produces a protective coating that is unaffected by the abrading that occurs in handling the forms.

Eliminating the labor of coating and scraping the forms between each pour, it reduces the frequency of applications and will not raise the grain of wood. The first coat retards weather-checking even when applied on old forms. One application is effective for an average of four pours. The forms may be used immediately after application, since no drying or curing is necessary. **Form Kote, Inc., CE 5-126, 700 West Virginia St., Milwaukee 4, Wisc.**

Clamshell Bucket

TO SPEED SHAFT MUCKING AND EXCAVATING, a new type clamshell bucket is being introduced. It is a pneumatic closing type for use with single drum hoists. Both the $\frac{3}{8}$ and $\frac{5}{8}$-cu yd sizes are designed to accommodate either the Ingersoll-Rand or the Gardner-Denver air hoist. The air hoist is so designed that when the chain is released the jaws of the bucket hold their positions. The upper structure is redesigned to permit mounting the air hoist directly on the vertical center line.

Safety has been a major factor in redesigning the bucket; workmen can now

Pneumatic Bucket

control the bucket's operation through open and closed chains. All external edges are streamlined and the bucket is well balanced. It operates on 85 to 100-lbs air pressure. **Blaw-Knox Company, CE 5-126, Farmers Bank Building, Pittsburgh, Pa.**

Abrasive Blade

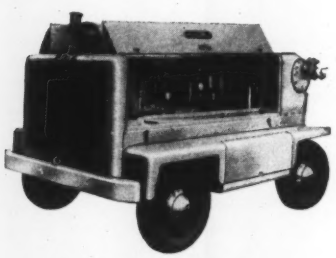
A NEW BREAKAGE-RESISTANT ABRASIVE BLADE has recently been announced. The new blade provides both economy and safety. Reinforced throughout the blade with tough fiber glass, the new model Tuffie has 3-ply reinforcing around the hub on both sides for protection when cutting. It features friction-free sides which add hundreds of cutting edges to each blade. Both sides of the blade are covered with these raised cutting edges, which cut faster, cleaner, and eliminate drag. This 3-ply breakage-resistant blade is available in 12-in., 14-in., and 18-in. diameters. **Eveready Briksaw Company, CE 5-126, 1509 S. Michigan Blvd., Dept. 323, Chicago 5, Ill.**

Drafting Pencil

A COLORED DRAFTING PENCIL that blueprints perfectly and greatly simplifies complicated technical drafting has been recently introduced in the United States. Called Mars-Lumochrom, it answers a long-standing need for a colored pencil with all the fine drafting characteristics of high-quality black graphite drafting pencils. All 24 colors are water-proof, easy to erase, do not smear or fade, and hold a fine point. **J. S. Staedtler, Inc., CE 5-126, 25 Dicarolis Court, Hackensack, N. J.**

Portable Compressor

A NEW 600-FT ROTARY PORTABLE COMPRESSOR, the Airvane, for use in the construction, mining and quarry industries, is both modern and functional in appearance and operation. The result of several years of research and field testing, the Airvane rotary is built for rough field usage. Exterior housing, of high-strength



600-ft Rotary Compressor

steel, is weather-proof. A low center of gravity and a short turning radius are combined for unmatched maneuverability. The thermal by-pass feature, heart of the Airvane temperature control system, results in uninterrupted performance and economy. A controlled-velocity filter-separator unit with primary and secondary action removes oil from compressed air with notable efficiency. **Joy Manufacturing Company, CE 5-126, Oliver Building, Pittsburgh 22, Pa.**

Off The Road Trailers

A FLEXIBLE TRAILER UNIT for use on soft ground or off the road is designed so that either track dolly may be used as the steering dolly. The trailing dolly is locked in position and either drawbar will fit both ends of both dollys. Standard kingpins are furnished so it is a simple

Flexible Trailer Unit

matter to remove one of the dollys in the field and maneuver the trailer with a standard over-the-road tractor. Regular wheeled dollys may be substituted for the track dollys. Rolling tailpipes and stake-pockets are provided for ease of loading and binding the load. The trailers have a capacity up to 60-tons. **Birmingham Manufacturing Co., CE 5-127, P. O. Box 1351, Birmingham, Ala.**

Graphic Visual Control Board

INFORMATION OR OPERATIONS can be graphically displayed on the Boardmaster. Material is typed or written on interchangeable cards and posted on an aluminum board. Information is easily kept up to date. This method is ideal for recording and illustrating engineering and construction data. The board is 24-in. by 38-in. A roller shade is also available to cover the board when confidential information is posted. **Graphic Systems, CE 5-127, 55 West 42 St., New York 36, N. Y.**

Telescoping Vibratory Screed

A NEW PIECE of heavy-duty, vibratory screed equipment is now being used, featuring a telescoping beam. By loosening several bolts the shoe-plate and rigid main frame can be telescoped to give any desired shoe-plate contact from 22-ft, 6-in. to 36-ft in fractional inch increments with one set of beams and from 15-ft, 6-in. to 23-ft with a second set. Because of the telescoping feature, which does

(*Continued on page 128*)

Gurley | ***Current Meters for measuring stream velocity in:***

Fresh water—rivers, streams, canals, lakes

Salt or brackish water—with a newly-designed salt water model

Shallow or sluggish streams—with the Pygmy Current Meter

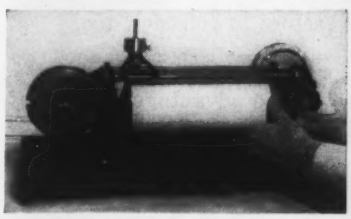
Industrial waste and sewage—where solids permit ...the Gurley Current Meter is made of non-corroding materials.

Gurley Current Meters have been the standard of the profession since 1870. Highly-standardized, easily-disassembled for cleaning...simple, precise and rugged. Write for "Gurley Current Meters" (Bulletin No. 700).

Gurley Graphic Water Level Recorders

Continuous record on graph chart for 24 hours or 8 days. Positive response to fluctuation by float, perforated tape and sprocket wheel. Finest quality "Chelsea" marine clock. Metal base and cover. Made of non-corrosive materials throughout. Ranges 1 to 40 ft., or 30 cm. to 12 meters.

Use Gurley Graphic Water Level Recorders when you need dependable records of reservoirs, hydro plants, sewers and sewage systems, irrigation and stream gaging. *Write for Bulletin No. 50 and details on Gurley Water Level Recorders.*



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W. & L. E. GURLEY HYDRAULIC INSTRUMENTS DIVISION
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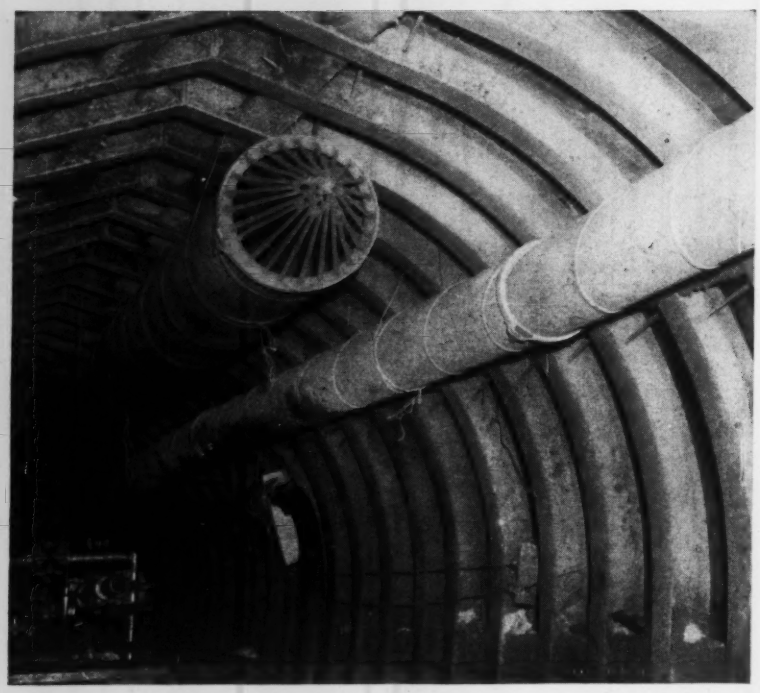
Gurley—Since 1845

SHORT CUT THAT CUTS COSTS



With the accent on speed in construction work, Naylor pipe has proved a practical help in providing a dependable short cut on ventilating lines.

The combination of this lockseamed, spiralwelded pipe and the one-piece Naylor Wedge-Lock coupling gives you lines that can be installed faster and easier than by other methods. The light weight of the pipe not only speeds the installation but, in addition, the exclusive Naylor structure permits the use of lighter gauge material which reduces costs without sacrificing performance. High salvage and re-use value are other economy factors to consider, too.

For moving air and water and for other materials handling jobs, it will pay you to look into all the advantages offered by Naylor pipe and Naylor Wedge-Lock couplings. Write for Bulletins No. 507 and No. 514.

NAYLOR PIPE

NAYLOR PIPE COMPANY
1281 East 92nd Street
Chicago 19, Illinois

Eastern U. S. and Foreign Sales Office: 350 Madison Avenue, New York 17, New York

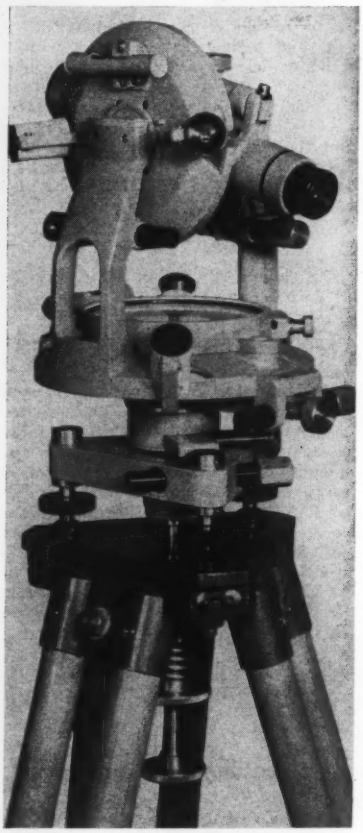
EQUIPMENT MATERIALS and METHODS

(continued)

away with beam overhang and the need for additional screeds of various lengths, the screed can be operated close to walls. Deep thorough compaction is gained by use of extra wide shoe-plates. **Creative Metals Corporation, CE 5-127,28, 1290 Powell St., Emeryville, Calif.**

Engineers Compass Transit

AN OUTSTANDING HIGH PRECISION INSTRUMENT is built in the American standard with an erecting eyepiece, double center, ocular prism and four screws.



Precision Transit

The optical plummet permits working under any weather conditions. For extreme observation an ocular prism is attached on the telescope. The reading of the horizontal circle is 30-sec, and of the vertical circle 1-min. **Geo-Optic Company, CE 5-128, 170 Broadway, New York 38, N. Y.**

Here's new lower-cost protection for your light-load excavations

FOSTER LIGHTWEIGHT PILING—

delivered immediately to your job site

This is the most economical sheeting available for smaller excavation jobs . . . a piling you can use for short-cut tricks (such as driving to minimum diameter circles of 13′). This new Foster light-weight piling offers the greatest strength, pound for pound, of any light-weight piling made, requires no special rig or tools for driving. New box-type corrugation gives easier driving and easier recovery, lets you work faster . . . and the special interlock design won't jam, permits the simple locking of sheets together without sliding one into the other the entire length. With a new higher section modulus, you can use lighter gauge, less bracing, easier working conditions—thus benefit from lower all-around costs that make wood piling outmoded forever . . . *for any job.* You can pull and re-use this high-strength piling again and again. Immediate deliveries in any length from Foster warehouse stocks—Rental or Sale. Investigate these special advantages . . . get our quotation for your next job.

handled by hand . . .

no special rigs

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PITTSBURGH 30, NEW YORK 7, CHICAGO 4, HOUSTON 2, ATLANTA 8, LOS ANGELES 5

for: SHORE PROTECTION, SUMP PITS, SEWER TRENCHES, CORE WALLS, COFFERDAMS, CUT-OFF WALLS, ABUTMENTS, BULKHEADS, BUILDING EXCAVATIONS

Steel-Sheet Piling, Pipe for Piling, and H-Bearing Pile, Rails, Track Equipment, Pipe, and Pipe Fabrication

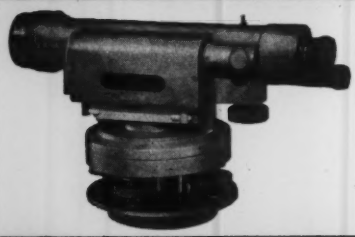
SURVEYORS!

Save time
Save money

NEW LEVEL with

Adjustable double bubble always visible THROUGH SAME EYEPIECE as cross hairs and field.

DOUBLE BUBBLE



is "MISTAKE FREE"

- No need to turn telescope during leveling
- American type—erecting eyepiece, 4 leveling screws
- Unbelievably fast and accurate, yet simple-to-use.. Economical!

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Please send me Booklet A with information on Fennel . . .

☐ Double bubble ☐ Alidades
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.....

EQUIPMENT MATERIALS and METHODS

(continued)

Weld-Crete

A JOB-PROVED BONDING AGENT permanently bonds new concrete to old concrete. It will also permanently bond new concrete to brick, wood, metal and many other surfaces. A free-flowing liquid agent, a little heavier than paint, it is applied with either a brush, spray gun or a roller. Weldcrete eliminates the need for costly, time-consuming surface preparation, and forms a three-way mechanical, chemical and adhesive bond that is permanent. It is unaffected by fire, climatic conditions, and chemicals. **Larsen Products Corporation, CE 5-130, 4934 Elm St., Bethesda, Md.**

Power Scraper

NOW AVAILABLE is the new CCS Cobrette 10-yd self-propelled scraper with fluid coupling drive, a positive power "gear steer" actuated by hydraulic rotary cylinders. Rated at 7.5-cu yd struck

CCS Cobrette

and 10-cu yd heaped, the 143-hp diesel powered unit has speeds up to 30-mph. The specially designed front end, tractor frame, and power train were specially designed for pushing, enabling two or more Cobrettes to assist each other in loading. The units are recommended for use as a one-man team. **Wooldridge Manufacturing Division, Continental Copper & Steel Industries, Inc., CE 5-130, Sunnyvale, Calif.**

Augers

AN ALL-PURPOSE AUGER, a tool that cuts its way through permafrost, hard packs and other difficult terrains including solid rock formation, is being used successfully on a U. S. Defense project in the Arctic. In everyday field use, the tool is regularly

(*Continued on page 132*)

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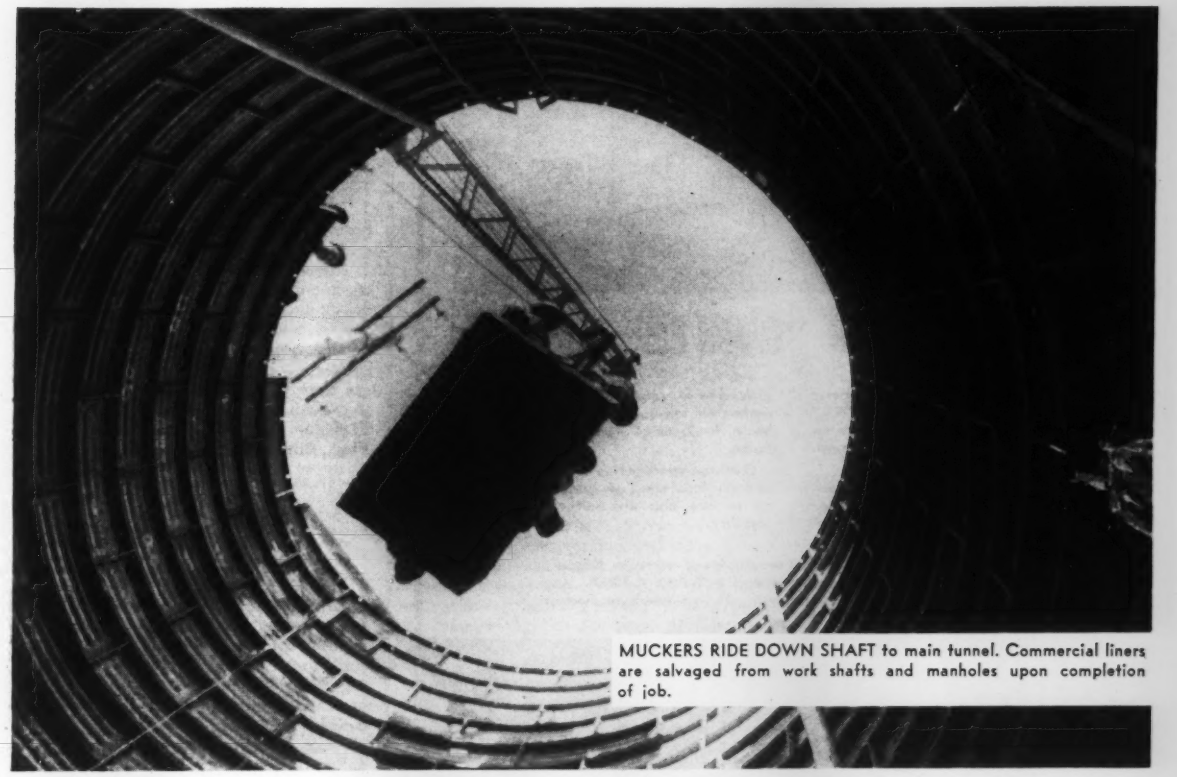
2082 ST. CATHERINE ST. WEST, MONTREAL



MUCKERS RIDE DOWN SHAFT to main tunnel. Commercial liners are salvaged from work shafts and manholes upon completion of job.

Inside Bolting of Commercial Liner Plates and Ribs Speeds Sewer Tunnel to Early Completion . . .

• A major factor in the speedy construction of the Central Schuylkill East Side Interceptor System of Philadelphia is the use of Commercial steel liner plates and posts.

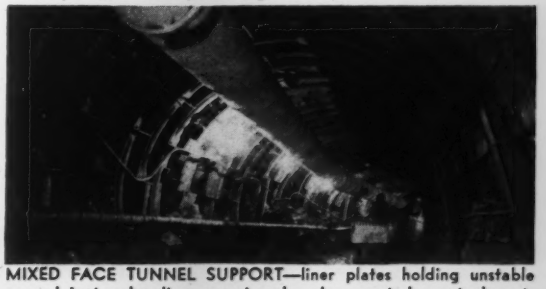
Four thousand eight hundred feet long and averaging thirty-five feet below the surface, this tunnel passes under railway lines and heavy city traffic . . . demanding roof support of maximum strength.

To provide the needed strength, safety, ease of handling and simplified installation, Commercial Shearing steel liner plates and posts were installed. Bolted from inside the tunnel with only a "spud wrench," Commercial liner plates and posts could be installed faster than any other support, even by unskilled work crews . . . an important safety factor when working in unpredictable earth and rock formations.

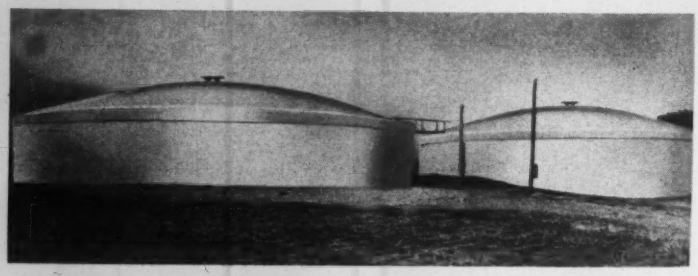
Commercial steel liners bent to suitable radii for tunnels or shafts four feet or larger in diameter, are available in thicknesses 1/8″ to 3/8″. For complete details on how you can cut days off your tunnel completion schedule, write to Dept. C-18, The Commercial Shearing and Stamping Company, Youngstown, Ohio.

COMMERCIAL *shearing and stamping*
YOUNGSTOWN, OHIO
CHICAGO, ILLINOIS
SALT LAKE CITY, UTAH

HEADING AND BENCH TUNNELING—removing hard bench, muckers move ahead. Commercial combination radii liner plates are in place in soft top heading.



MIXED FACE TUNNEL SUPPORT—liner plates holding unstable ground in top heading are pinned and supported on steel posts bearing on stable ground.



PRE-STRESSED "GUNITE" TANKS

Above are shown two 80′ diameter 750,000 gallon pre-stressed "GUNITE" water storage tanks with "GUNITE" dome roofs. We built these tanks for the Borough of Schuylkill Haven, Penn.

Pre-stressed "GUNITE" produces a water storage tank which is bottle tight and maintenance free. They may be built either at ground level, completely underground with earth covering over the dome roof, or may be in the form of stand-pipes or elevated tanks.

Our experience in this field includes scores of tanks and silos of many types ranging up to two and one-half million gallons capacity.

The use of "GUNITE" for repair and construction of reservoirs, bridges, buildings, etc., is illustrated and described in Bulletin B-3000. We will gladly send a copy at your request. On your letterhead, please.

CEMENT GUN COMPANY
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GENERAL OFFICES – ALLENTOWN, PA., U. S. A.

MANUFACTURERS OF THE "CEMENT GUN"

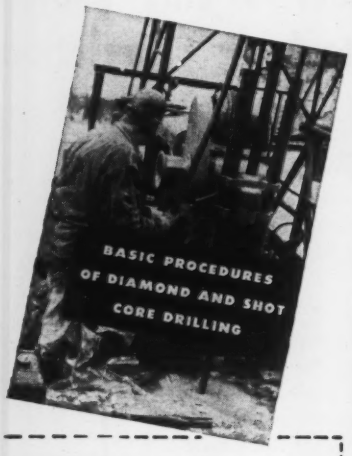
NEW

CORE DRILLING MANUAL AVAILABLE

To meet the growing need for a non-technical operational book on Core Drilling, the Acker Drill Company has prepared at considerable expense, a handy, pocket size book with over 100 illustrations.

For a fraction of the cost of preparation and printing, we'll gladly send you postpaid a copy of this new book for only $1.00. If not entirely satisfied, return the book within 7 days for complete refund.

But hurry, send the coupon, today!



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Here's my check for $1.00.* Rush me a copy of, "Basic Procedures Of Diamond and Shot Core Drilling."

I understand, that my money will be refunded if I am not satisfied, and the book is returned within 7 days.

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*Write for quantity discounts on orders of 6 books or more. CE

EQUIPMENT MATERIALS and METHODS

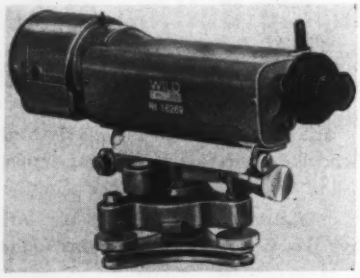
(continued)

boring limestone, coral rock, sandstone and frozen soil.

The auger features a tapered helix of chrome-molybdenum steel with a series of heavy-duty cutting bits stepped around the edge of the spiral, and a hollow mill cutting head in lieu of the conventional piercing point. The drill head and bits are tipped with sintered tungsten carbide to provide the most durable cutting edges. **Alaskaug, Inc., CE 5-130,32, 620 Keith Bldg., Cincinnati 2, Ohio.**

Precision Level

THE MODEL N-3 is designed to meet the highest requirements in precision, convenience and all around performance under rugged field conditions. With the Invar precision leveling staff, the N-3 has an accuracy of plus or minus 0.01-in. in one mile of single leveling. The telescope, internally focused and with coated lens, has the unusually high magnifying power of



Model N-3

42X. Three models of the N-3 include the standard metric, special engineer, and special industrial, all with tilting screw, coincidence level and built-in optical micrometer. **Wild Heerbrugg Instruments, Inc., CE 5-132, Main at Covert Sts., Port Washington, N. Y.**

Heavy-Duty Vise

A HEAVY-DUTY VISE is being introduced to the construction field. Weighing 150-lb, it is of semi-steel construction. The vise has a gripping surface of 5 by 4-in. on the face of each jaw with a total depth of approximately 6-in. The top of the jaw has an area large enough to be used for riveting or as an anvil surface when neces-

TIDE GATES

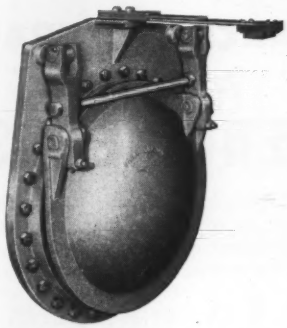


Figure B-175. Type M-R Gates designed especially for application to centrifugal pump discharge lines. A rubber seating ring is inserted in the seat to absorb the slap which occurs when pumps stop. A flexible bar connection is arranged between the hinge links to provide a stop for the gate shutter to prevent the outer edge of the shutter from tipping downwardly when flow abruptly ceases. Smaller sizes of gate are provided with a bumper arrangement to prevent the shutter being forced too widely open when flow starts.

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Bibliography on Machinery Foundations

The Engineering Societies Library announces its new Bibliography (No. 11), which provides annotated references from 1924 to 1955 on machinery foundations —design, construction, vibration elimination.

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EQUIPMENT MATERIALS and METHODS

(continued)

sary. So constructed that it can be left out-of-doors permanently without affecting its operation, the vise may also be used for the bending of heavy iron bars. A 5-in. pipe grip gives maximum holding power for freeing fittings and nuts. **Athol Machine & Foundry Company, CE 5-132,33, Athol, Mass.**

Underground Pumping Station

A PREFABRICATED AUTOMATIC LIFT STATION for underground installation is an economical and reliable unit for use with existing sewage systems and for handling extensions to existing mains. Employed to raise sewage to the level of existing mains or treatment facility, the pumping station features improved equipment and controls.

The packaged plant is assembled and welded at the factory of heavy steel plate, reinforced against exterior hydrostatic forces. Station dimensions are usually not less than 7-ft in diameter and 7-ft high. Station capacities can be as high as 600-gpm at heads up to 80-ft. **Zimmer & Francescon, CE 5-133, Moline, Ill.**

Roller

A NEWLY DESIGNED AND IMPROVED KEN-ROLL has been introduced. Principal changes from previous models are in increased weight range, in appearance, safety and driver comfort. The driver's seat is now more fully enclosed, cushioned, adjustable and has an engine heat shield.

Featured still on the Ken-Roll is the close tolerance of $\frac{1}{2}$-in. clearance on the right-hand side to permit rolling close to walls and posts. Compression roll, with water ballast, delivers up to 85-lb per lineal inch; with water and steel ballast, the pressure goes up to 138-lb per lineal inch. The sprinkler tank has a 93-gal capacity. **Pfahler Manufacturing Company, CE 5-133, Galion, Ohio.**

Adjustable Curve Drafting Instrument

THE MODEL E ADJUSTABLE CURVE is an instrument composed of an upper and lower bar, and two connecting links. The lower bar is a telescoping slide which can be locked at any desired position within fixed limits. The upper bar is flexible and is designed to form a circular curve

(*Continued on page 134*)

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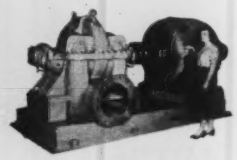

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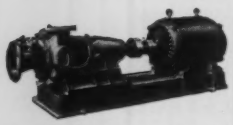

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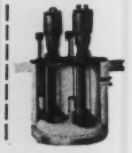

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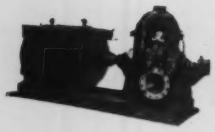

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EQUIPMENT MATERIALS and METHODS

(continued)

when stressed. As the lower bar is shortened, the upper bar takes the shape of a circular curve of increasing curvature.

The Model E reads in degree of curve for a scale of 1-in. to a 100-ft. It also has graduations which read actual radius of curvature in inches. The instrument is accurate to within $^1/_{16}$-in. **Albert G. Daniels, CE 5-133,34, 109 Chalmers St., Winnsboro, S. C.**

Copper Cut Saw

A NEW CUT SAW, designed exclusively for cutting copper, is being introduced. Its chief feature is that it will cut copper without a burr on either the outside or the inside. Thus, reaming is unnecessary, and each cut slips into the fitting without burring. Tests have proved that several thousand cuts can be made before the wheel requires sharpening. From seven to eight pieces of $^3/_4$-in. and $^1/_2$-in. copper tubing can be cut at one time, with a length indicator assuring accurate cutting.

Made of aluminum for easy portability, the copper cut saw weighs approximately 90-lb. It requires no special skill to operate. Power is supplied by any 110-v outlet, with no special wiring needed. **Collins Machinery Corporation, CE 5-134, 5474 Alhambra Ave., Los Angeles 32, Calif.**

Template

A NEW TEMPLATE enables a draftsman to draw dot and dash lines with a rapid stroke of a pencil or ball-point pen. Produced by a professional engineer for making piping drawings, the template is applicable to any type of architectural or mechanical drawing where various broken-line combinations are desired. The template will produce six different lines: long dash, short dash, long dash and dot, short dash and dot, long dash and two dots, and short dash and two dots. The hardness of the pencil determines the density of the line.

Made of exceptionally strong and durable transparent Mylar plastic, it is 0.0075-in. thick. The template is used by placing a straight edge on the desired stencil and quickly drawing the line. The price is $1.25. **Dot-N-Dasher, CE 5-134, Box 668, Cresskill, N. J.**

NEWS ITEMS
BEGIN ON PAGE 126!

Opportunity For ARCHITECTURAL AND CIVIL ENGINEERS

THE Technical Department, Douglas Fir Plywood Association, has three excellent openings in its Tacoma, Washington, research laboratory:

1—ENGINEER ANALYST. Creative engineering for the plywood industry. An especially attractive opportunity for a civil engineer interested in structural research. Mathematical analyses of conventional and unconventional structural applications of plywood, laboratory testing of plywood products, assemblies and fastenings. Good knowledge of mathematics, mechanics, and strength of materials essential. Experience in structural design, laboratory techniques and statistical methods desirable.

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3—ENGINEER CORRESPONDENT who can, in response to inquiries, advise and assist specifiers in proper use of plywood. A civil or architectural engineering graduate with a knowledge of good construction practice and a command of written English will find this an excellent opportunity.

The location, Pacific Northwest, is one of the nation's fastest growing areas; long-range development of fir plywood and related wood products means an attractive future. The salary for all three openings is open and will depend on qualifications. Write fully—experience, education, salary requirements. N. S. Perkins, Technical Director, Douglas Fir Plywood Assoc., Tacoma 2, Wash.

LITERATURE AVAILABLE

DRAFTING DESK—A colored folder describes in detail the Draft-a-Matic, a new type of drafting desk, which permits the draftsman to work more efficiently yet in perfect seated comfort. The outstanding feature of the desk is the roto-positioner, an easy-to-operate control, which positions the drawing in the most efficient drafting area. This feature as well as the sliding reference top, adjustable drafting platform and height adjustment control are thoroughly illustrated in the brochure. **The General Fireproofing Company, CE 5-135, Youngstown, Ohio.**

SWITCH STANDS—A new catalog, No. 389, titled "Switch Stands" has been compiled and published recently. Its contents deal with stands for narrow and standard gauge service. The many illustrations adequately tell the story of each of the several models which the company makes. **Bethlehem Steel Company, CE 5-135, Bethlehem, Pa.**

METAL LATHING—The 1956 edition of "Specifications for Metal Lathing and Furring" is now available. Covering all types of metal construction, this explanatory 16-page booklet includes specifications for solid and hollow partitions; wall furring; and contact, furred and suspended ceilings. Also in the booklet are fire-resistive ratings and tables denoting various spans and spacings for supporting metal lath and plaster ceilings. All tables have been rearranged for more convenient reference. **Metal Lath Manufacturers Association, CE 5-135, Engineers Bldg., Cleveland 14, Ohio.**

CURTAIN-WALL DATA—Aluminum window-wall, curtain-wall and steel window-wall systems are the subject of a new data reference file. Included in this portfolio are two brochures with specifications and detailed information on the curtain-wall system as well as seven folders of diagrams illustrating various window and curtain-wall systems. **The William Bayley Company, CE 5-135, 1200 Warder St, Springfield 99, Ohio.**

WATER LEAK DETECTOR—A comprehensive and well-documented 20-page bulletin, No. 1301, of interest to engineers and personnel of municipalities and public works dealing with water conservation and water wastage, has been prepared. The bulletin describes the Pitot assembly consisting of a pitot rod, manometer, and pitot recorder, used to locate hidden leaks in water mains. Valuable data on care of equipment, installation instructions, theory of operation and formulae that will help control water wastage is contained in this bulletin. **Simplex Valve & Meter Company, CE 5-135, 7 East Orange St., Lancaster, Pa.**

Baker River dam site uses seismic survey to map bedrock

Puget Sound Power & Light Company's proposed dam on the Upper Baker River in the state of Washington, lay in rugged country. Stone & Webster, engineers for the job, called in Gahagan to make a preliminary subsurface investigation. Problem was to determine bedrock elevations at the site of the embankment adjoining the dam. A Gahagan Seismic Survey Crew, using portable equipment, completed the assignment in eight days. They provided a profile of widely varying bedrock that could not have been duplicated by other means without a much greater expenditure of time and money. Gahagan Seismic Surveys routinely save design engineers time and money, provide more information in construction of dams, highways, power plants, bridges, etc. Write for Bulletin 2, Geophysical Survey Division, Gahagan Dredging Corporation, 90 Broad Street, New York 4, N. Y.

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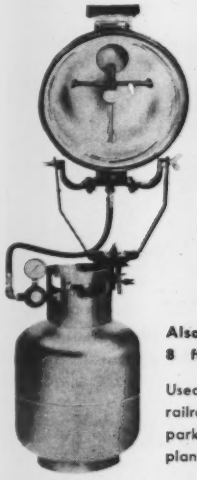

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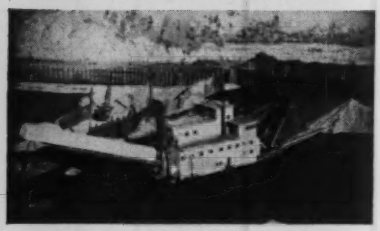

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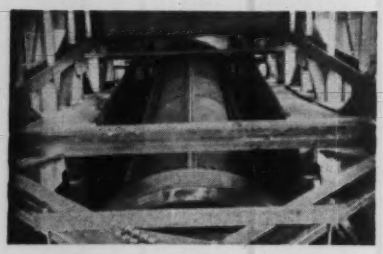

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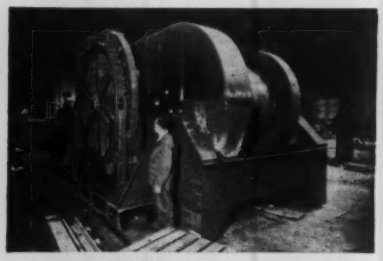

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From the MANUFACTURERS

MATERIALS HANDLING EXPOSITION: Towmotor Corporation will feature their new fork lift trucks at the forthcoming Materials Handling Institute's Exposition. June 5–8 is the date, and the Cleveland Public Auditorium will be the setting. Towmotor officials believe their new models will present an entirely new concept in modern materials handling techniques... **SCHOOL CONSTRUCTION FINANCING:** The Reynolds Metal Company has instituted a plan to provide lease-purchase financing for new public schools anywhere in the nation. The company will serve as a non-paid agent for any school district to arrange the design, construction, financing and equipping of a school building to its own particular needs and specifications... **GUARANTEE EXTENDED:** The Clay Sewer Pipe Association has extended the guarantee on vitrified clay pipe from 50 to 75 years... **WATER TEST TANK:** A 600,000-gal water tank in which sections of airplane fuselage are submerged to prove the structural strength of the airframe has been constructed by Western Waterproofing Co. The tank was expressly designed for Lockheed's new C-130 Hercules Prop-Jet transport plane... **OHIO RIVER WILL GET FACE-LIFTING:** Dravo Corporation is the low bidder for construction of the Markland Locks on the Ohio River. The new installations will replace five obsolete locks and dams... **OVERNIGHT PAINTING:** The introduction of Luminall concrete floor paint, which dries in only 20 to 40 minutes indoors, makes possible overnight painting of industrial concrete surfaces, with production work resumed over them in the morning. The new paint was developed by the National Chemical and Manufacturing Company... **LOGGING MACHINES:** Clark Equipment Company will manufacture a new logging machine, specially designed for use on rough terrain, which will automatically load and unload 3½-tons of pulpwood... **MOVING SIDEWALKS:** Wrigley Field in Chicago has recently purchased eight Speedwalk passenger conveyor units to carry fans from ground level to grandstand, and from grandstand to upper deck. The Speedwalks are manufactured by the Stephens-Adamson Manufacturing Company... **NEW SERVICE OPENED:** Builders-Providence, Inc., Omega Machine Co., and Proportioneers, Inc., three divisions of B-I-F Industries, Inc. have established a new service to aid in the solution of problems involving meters, feeders and controls. Six district engineers have been appointed to serve a regional area of several states. Heading the new service will be M. E. Rogers, Project Sales Manager of Builders-Providence, Inc... **APPOINTMENT:** Dan W. Oram has recently been named as Executive Director of Sales for the Klemp Metal Grating Corporation.

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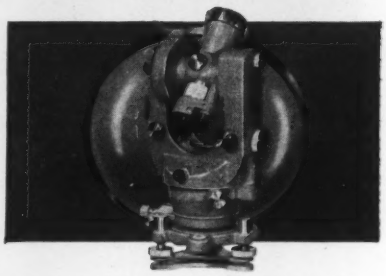

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925. **Wave Run-Up on Shore Structures, by Thorndike Saville, Jr.** (WW) The run-up of waves on shore protection structures has been studied by the Beach Erosion Board. The author describes the tests used to determine the run-up related to wave steepness, structure type, and depth of water.

926. **Houston, Texas, Floodway, by Kenneth Heagy.** (WW) The most suitable flood protection plan for Houston provides for the continued operation of the Barker and Addicks Reservoirs, and for the clearing, strengthening, enlarging, and lining of the Buffalo, Brays, and White Oak Bayous.

927. **Trinity River Flood Control Project, by James A. Cotton and W. E. Wood.** (WW) A Federal project of four reservoirs and two floodway improvements on the Upper Trinity River, Texas, is described. This project gives protection to agricultural lands and to the urban areas of Fort Worth and Dallas.

928. **Design of Venturi Flumes in Circular Conduits, by Edwin A. Wells and Harold B. Gotaas.** (SA) The coefficient of discharge for Venturi flumes and the hydraulic aspects of Venturi flow are discussed. The experimental studies and results show the influence of various flume dimensions.

929. **Intermittent Discharge of Spent Sulfite Liquor, by Herman R. Amberg and Robert Elder.** (SA) Intermittent discharge of spent sulfite liquors into the Columbia River is proposed to control slime growth, which can be controlled if the wastes are discharged intermittently into a river of sufficient volume and high velocity.

930. **The Analysis of Water Samples for Cyclical Variations, by Alex N. Diachishin.** (SA) The tidal variation of bacterial populations is examined from a mathematical standpoint. The statistical variation of samples collected during one tidal cycle is compared to the theoretical variation of the M.P.N. test.

931. **Water Supply in Arctic Areas: Design Features, by Lloyd K. Clark and Amos J. Alter.** (SA) Long sub-zero winters and permanently frozen ground impose restrictions in the design of Arctic water systems. Design features are suggested for water source, treatment, distribution, and storage.

932. **Discussion of Proceedings Papers** 592, 686, 687. (SA) D. R. Stanley closure to 592. W. J. Oswald and H. B. Gotaas closure to 686. C. N. H. Fischerstrom closure to 687.

933. **New Test for Control of Cohesive Soils in Rolled-Fill, by J. MacNeil Turnbull.** (SM) The "drop" test controls the placing of rolled-fill under modern rapid rates of construction. One test supplies the optimum wet density and the difference between field and optimum moisture.

934. **Stabilization of Materials by Compaction, by W. J. Turnbull and Charles R. Foster.** (SM) This paper shows, for cohesive soils, how strength varies with water content and density and how variations in rolling and lift thickness affect the density and strength obtained in field compaction.

935. **Bridge Clearances: Policies and Practice, by Eugene W. Weber.** (WW) Highway transport, the resurgence of waterways traffic, and the continued development of railroads have resulted in radical changes in the bridge clearance problem. Its history and the steps necessary for its solution are developed.

936. **Bridge Clearances: The Interest of the Bureau of Public Roads, by Walter Kurylo.** (WW) A new concept of national transportation policy concerning bridge clearances for navigational needs is being developed. It protects the public interest rather than one form of transportation.

937. **Bridge Clearances: Problem Needs Realistic Approach, by William E. Cleary.** (WW) The need exists for a practical approach to bridge clearances. An agreement has been reached between navigational and other interests relative to clearances along the Connecticut Expressway.

938. **Bridge Clearances: The Operator's View, by N. L. Caruthers.** (WW) Marine interests have become increasingly aware of the problem of bridge clearances across navigable waterways. The thesis is developed that each crossing should be considered on its own merits.

939. **Bridge Clearances: Problems in Northeastern United States, by E. E. Dittbrenner.** (WW) This paper cites examples in northeastern United States where coordination between highway and waterway has been and can be beneficial and relates conditions here to those in the rest of the United States.

940. **Thrust Loading on Piles, by James F. McNulty.** (SM) Lateral load tests were performed on two separate projects for the National Advisory Committee for Aeronautics, Langley Field, Virginia. The field data and an approximate method of analysis are presented and discussed.

941. **Earthquake Resistance of Rock-Fill Dams, by Ray W. Clough and David Pirtz.** (SM) An experimental investigation of the effects of earthquakes on rock-fill dams with earthen cores is described. Results show these dams are resistant to earthquakes because of their flexible structure.

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942. Discussion of Proceedings Papers 548, 756, 757. (SM) T. F. Thompson closure to 548. No closure to 756. S. Leliavsky on 757.

943. Inelastic Buckling of Non-Uniform Columns, by John E. Goldberg, John L. Bogdanoff, and Hsu Lo. (EM) A numerical procedure is presented for calculating the critical loads of non-uniform, pin-ended columns in the elastic or inelastic range.

944. The Dynamic Response of Tall Structures to Lateral Loads, by L. Schenker. (EM) Some aspects are considered of the analytical procedures for computing the response of structures to dynamic forces. Only tall structures subjected to lateral forces or displacements are considered.

945. The Viscous Sublayer along a Smooth Boundary, by H. A. Einstein and Huon Li. (EM) If the sublayer is visualized as a steady, quasi-laminar flow, difficulty is encountered in the physical description of the transition to the turbulent part of the flow. The proposed model visualizes a periodic growth and decay of the sublayer.

946. Discussion of Proceedings Papers 670, 671, 695, 817, 818. (ST) T. E. Stelson and F. T. Mavis closure to 670. J. H. Weiner, M. G. Salvadori, and V. Paschkis closure to 671. B. G. Johnston and A. Mathews closure to 695. R. E. Glover, V. E. Hansen, J. N. Luthin, C. S. Yih on 817. H. G. Lorsch on 818.

947. Report on Experiences with Water Wheel Unit Alignment, by S. O. Schamberger. (PO) In this paper an attempt has been made to collect and correlate some of the proven cases of water-wheel misalinement experienced after original erection, to study the causes of this behavior, to note the methods used in correcting them, and to suggest a method for checking a misalinement condition.

948. Hydraulic Design of the Sandow Pumping Plant, by R. T. Richards, E. T. Keck, and J. Junget. (PO) There is described the hydraulic design of the Sandow Pumping Plant which combines large vertical pumps, long and irregular pipeline profiles, and surge and flow control problems.

949. Steel Lining for Pressure Shafts in Solid Rock, by E. W. Vaughan. (PO) The methods used in the design of two pressure shafts in Brazil are discussed in detail and their general features compared with those of other shafts constructed elsewhere; pertinent details of design and constructon are presented.

950. Project Construction at McNary Dam, by S. G. Neff and J. J. Morton. (PO) This paper discusses the project construction which will include the general requirements, the general plan of construction, the construction operations, and some of the special construction features and problems.

951. McNary Dam—Coordination of Project Design and Construction, by Otto R. Lunn. (PO) On large, multi-purpose dams like McNary on the Columbia River, the design of the dam structures must of necessity be closely coordinated with construction.

952. Discussion of Proceedings Papers 700, 948. (PO) S. Leliavsky on 700. S. L. Kerr on 948.

953. Research Needs in Sediment Hydraulics, by Enos J. Carlson and Carl R. Miller. (HY) The tools available for solution of sediment problems encountered by the Bureau of Reclamation are discussed and the areas where research and development are needed to improve these tools are given.

954. Flood Plain Zoning as Supplement to Flood Control, by Emil P. Schuleen. (HY) Factors affecting flood plain development are considered and the limitations and ineffectiveness of various types of flood control measures are described. The need for flood plain zoning to control such development is presented.

955. Discussion of Proceedings Papers 745, 806, 826, 836, 838, 840. (HY) S. C. Happ on 745. N. H. Brooks, F. L. Hotes, J. A. Harder, C. H. Lee, R. T. Knapp on 806. R. D. Goodrich, C. F. Merriam and E. T. Schuleen, W. M. Snyder on 826. F. C. Craig, and L. J. Tison on 836. C. J. Keifer and H. H. Chu, R. Y. D. Chun, M. Hom-Ma, A. Newman, S. Kolupaila on, and corrections to, 838. D. M. Hershfield and W. T. Wilson on 840.

956. Geology of Some American Estuarine Harbors, by Parker D. Trask. (HY) The formation of numerous harbors in the United States are described. Most of these harbors show the effects of differential erosion.

957. Use of Zoning Principles in Flood Plain Regulation, by Joseph I. Perrey. (HY) Zoning ordinances for the protection of the water-carrying capacity of floodways should prohibit all construction that may reduce the floodway cross section or otherwise limit the capacity of the floodway.

958. Sewage Disposal in Sweden, by James Garner. (HY) Stockholm is faced with the problem of disposal of more sewage than can be handled with the present facilities. Increasing the sewerage systems has resulted in several engineering problems and solutions.

959. The Philosophy of Arch Dams, by Andre Coyne. (PO) This paper discusses the reasons for the inherent strength of arch dams, the evolution of basic criteria and arch dam shapes, and briefly touches on the economics, calculation of stresses, and the value of structural models.

960. Trial Load Studies for Hungry Horse Dam, by R. E. Glover and Merlin D. Copen. (PO) A brief history is given of the development of the Trial Load method for stress analysis of arch dams and the application of these procedures to the design of the Hungry Horse Dam is described in detail.

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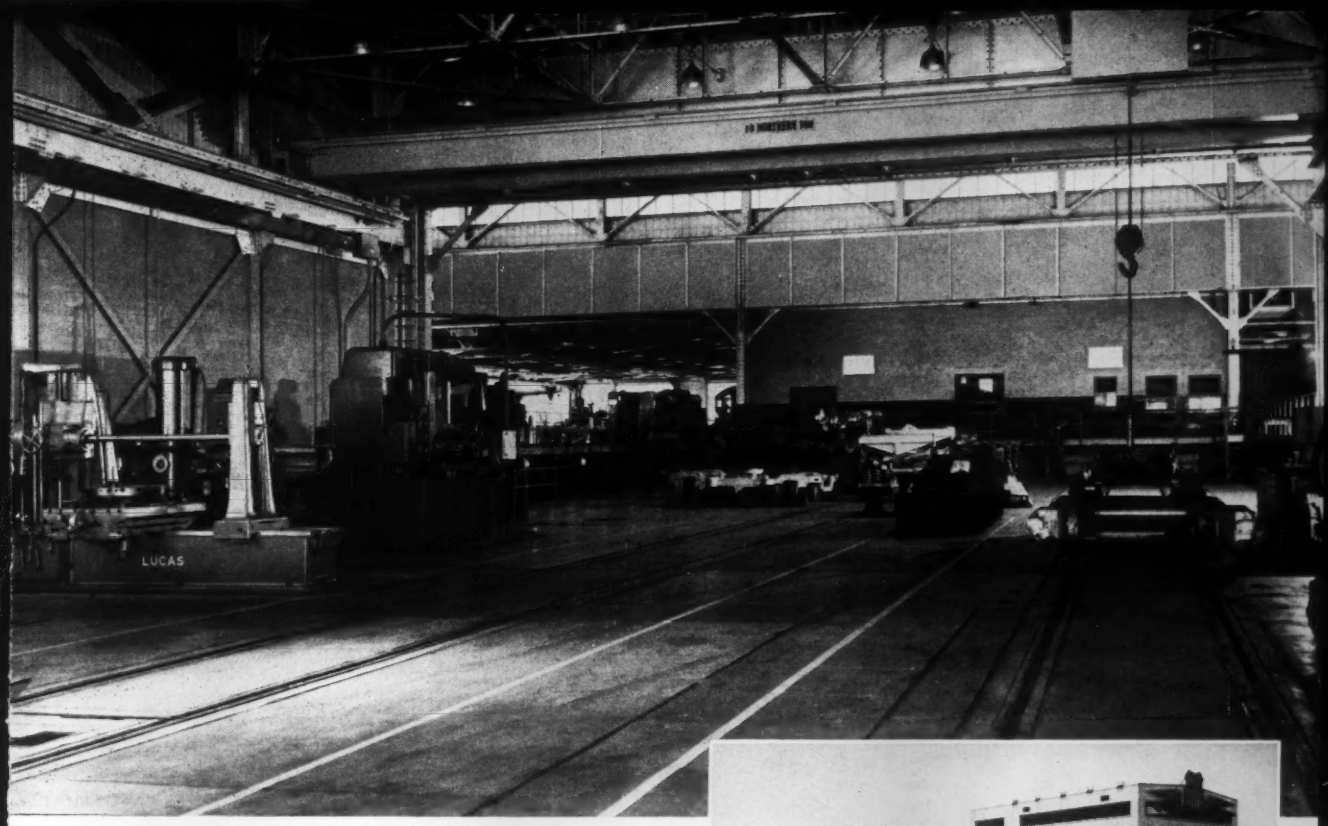

Union Pacific Railroad's new diesel repair and maintenance shop, Salt Lake City, Utah. Constructed by the company's own engineering department under the direction of W. C. Perkins, Omaha, Chief Engineer and R. M. Brown, Salt Lake City, District Engineer. William N. Stockton, Salt Lake City, Resident Engineer in charge of actual construction.

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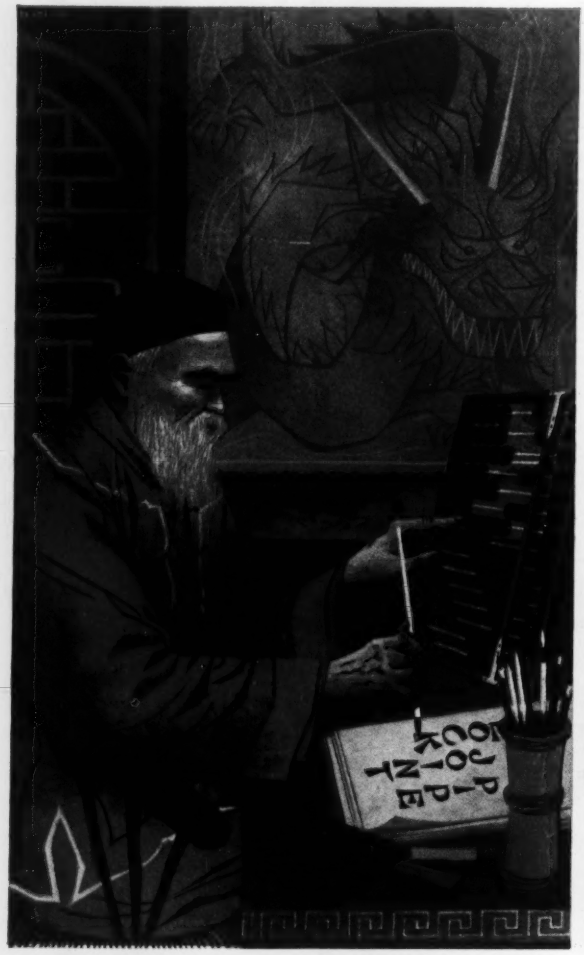

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